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FLOATING FOOT BRIDGE ACROSS BLUE RIVER AT MILLTOWN, IND.
(See page 242.)

LIME KILNS AT SALEM, IND.
(See page 249.)

# INDIANA.

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# DEPARTMENT

OF

# Geology and Natural Resources.

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## TWENTY-EIGHTH ANNUAL REPORT.

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**W. S. BLATCHLEY,**

STATE GEOLOGIST.

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**1903**

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INDIANAPOLIS:
WM. B. BURFORD, CONTRACTOR FOR STATE PRINTING AND BINDING.
1904.

THE STATE OF INDIANA,
EXECUTIVE DEPARTMENT,
INDIANAPOLIS, March 4, 1904.

Received by the Governor, examined and referred to the Auditor of State for verification of the financial statement.

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OFFICE OF AUDITOR OF STATE,
INDIANAPOLIS, March 4, 1904.

The within report, so far as the same relates to moneys drawn from the State Treasury, contains no statement.

D. E. SHERRICK,
*Auditor of State.*

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March 8, 1904.

Returned by the Auditor of State, with above certificate, and transmitted to Secretary of State for publication, upon the order of the Board of Commissioners of Public Printing and Binding.

GEO. B. LOCKWOOD,
*Private Secretary.*

---

Filed in the office of the Secretary of State of the State of Indiana, March 10, 1904.

DANIEL E. STORMS,
*Secretary of State.*

---

Received the within report and delivered to the printer this 10th day of March, 1904.

THOS. J. CARTER,
*Clerk Printing Bureau.*

*State of Indiana, Department of Geology and Natural Resources.*

INDIANAPOLIS, IND., February 20, 1904.

HON. W. T. DURBIN, *Governor of Indiana:*

DEAR SIR—I transmit to you herewith the manuscript of the Twenty-eighth Annual Report of the Department of Geology and Natural Resources, the same being for the calendar year 1903.

Respectfully yours,

W. S. BLATCHLEY,

*State Geologist.*

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# DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

INDIANAPOLIS, IND.

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W. S. BLATCHLEY, State Geologist.

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PLEASE ACKNOWLEDGE RECEIPT OF THIS VOLUME.

**In return, Scientific Books, Fossils, etc., and Implements of the "Stone Age" are acceptable.**

**State Museum, Room 126, Third Floor, State House.**
**Open to the public from 8 A. M. to 5 P. M., except on Sundays and legal holidays. Admission free.**

**Office of State Geologist, Room 89, Third Floor, State House.**

# INTRODUCTORY.

The most valuable feature of the present report of the Department of Geology is an accurate, sectional, geological map of the State. The data for this map have been gathered during the past nine years, or since the present Director assumed charge of the Department. Every boundary line between the different formations shown on the map has been traced in the field since then. Dr. T. C. Hopkins has had direct charge of the making of the original copy of the map. In its compilation he has used the field notes and maps made by Drs. Ashley, Siebenthal, Kindle, Foerste and other assistants on the survey. Besides these, he has incorporated the results of his own work in the oölitic limestone and sandstone districts, and also the results of much special field work done by him with a view of making the map as complete and accurate as possible. The map is on a scale of four miles to the inch, and shows every section comprised within the limits of the State, while the boundary lines are traced as accurately as possible through the sections they cross. In the deep drift-covered area of the northern part of the State it is impossible to trace the boundary between the formations, hence that portion of the map is left uncolored.

In order that the map may be as intelligible as possible to persons who have but little knowledge of geology, Drs. Hopkins and Foerste have prepared a special paper to accompany it, describing briefly the rocks of the different periods represented in the State. By using this paper in connection with the map, much of interest can be learned concerning the topography and general structure of the surface of the State.

The production of petroleum in Indiana has rapidly grown until that industry has become one of the greatest in the State. The price of the crude product during the past year reached the highest in its history, and averaged higher than during any previous year. This stimulated the sinking of many new bores which added quite an area to that hitherto productive. The output of Indiana oil for the year 1903 reached the enormous total of 9,177,722 barrels, which, at the average market price of $1.14 3-20 per barrel,

brought to the producers $10,476,369. More inquiries come to the office of the Department concerning oil than any other resource. In order to meet these inquiries a paper has been prepared giving in detail the developments and statistics of the industry in the State during the year. Accompanying this paper is an accurate map of the main Indiana oil field as it was on January 1, 1904.

The fourth paper in the volume deals with "The Lime Industry in Indiana." The burning of lime in the State has gradually grown from the days of the pioneers, when it was carried on in rude temporary kilns in each neighborhood where lime rock occurs, until it has become an important industry with hundreds of thousands of dollars invested. The paper describes and gives the general location of each kind of rock suitable for lime burning in the State; and also contains descriptions of all the lime burning plants now in operation. It is the first time that the Lime Industry has been given more than brief mention in any of the reports issued by the Department.

In the report for 1900, the writer predicted that the yearly output of Indiana coal would reach 10,000,000 tons before 1910. From present indications, it will more likely double that amount by the time mentioned, as the report of the State Mine Inspector shows that 9,992,553 tons were mined in the State in 1903. This was an increase of 1,229,356 tons over the output of 1902, which was the largest in the history of the State. The output in 1898 was 5,177,044 tons; the increase in five years was, therefore, 4,815,509 tons, or 93 per cent.

During the past three years there has been an absence of the customary strikes on the part of the miners, due to the biennial agreement between miners and operators. The prolonged strike in the Pennsylvania hard coal fields in 1902, causing thousands of tons of soft coal to be used instead of anthracite; the almost complete failure of natural gas in this State, and the unprecedented activity in manufacturing of every kind, were the principal factors causing the enormous output of Indiana coal in 1903. At one time in January of that year, mine-run bituminous coal was sold at $3.60 per ton at the mines in Vermillion County, and the average yearly price was far in excess of what it had ever been.

According to the report of Mr. Epperson, the relative rank of the 14 coal producing counties for the year 1903, together with

the output of each in tons and the amount of wages paid to miners was as follows:

TONS OF COAL PRODUCED AND WAGES PAID TO MINERS IN INDIANA IN 1903, BY COUNTIES.

| | *No. of Tons Produced.* | *Wages Paid.* |
|---|---|---|
| Greene County | 2,226,791 | $1,888,045 39 |
| Vigo County | 1,716,726 | 1,493,761 80 |
| Sullivan County | 1,553,338 | 1,264,436 99 |
| Clay County | 1,222,474 | 1,415,508 06 |
| Vermillion County | 942,165 | 748,447 77 |
| Parke County | 929,994 | 1,088,504 26 |
| Pike County | 484,228 | 449,931 99 |
| Warrick County | 315,641 | 214,481 75 |
| Vanderburgh County | 204,648 | 192,735 78 |
| Daviess County | 191,159 | 195,442 12 |
| Knox County | 137,949 | 122,591 61 |
| Gibson County | 46,700 | 51,233 06 |
| Fountain County | 16,620 | 13,336 19 |
| Perry County | 11,120 | 11,115 35 |
| Total | 9,992,553 | $9,149,572 12 |

Of the coal produced, 1,025,940 tons were block coal and the remainder bituminous. Clay and Parke counties alone yielded block coal; Clay County producing 586,381 tons and Parke County the remainder, or 439,559 tons. The output of block coal has fallen off nearly one-third since 1900, when 1,512,098 tons were mined. This decrease is in Clay County, where many of the old mines have been worked out. It is estimated that, at the present rate of output, the block coal of the State will be wholly exhausted in 20 years. The report of Mr. Epperson gives many other facts of interest relative to the coal industry of the State, being very full and complete in detail.

The report of the State Gas Supervisor, Mr. B. A. Kinney, of Marion, Indiana, follows that of the Mine Inspector. On account of the numerous bores put down in gas territory in search of oil, Mr. Kinney and his assistant were kept very busy in enforcing the law against the waste of gas, a large number of affidavits having been filed against offenders during the year. Being well acquainted with all parts of the territory and conscientious in the performance of his duty, the State Supervisor has reduced to a minimum the waste of any great portion of the small amount of

gas remaining. His report shows that the average gas well drilled during the year would have been considered a failure ten years ago, the great majority of them yielding less than 500,000 cubic feet a day when finished. A small area of comparatively virgin gas territory was opened up in northern Grant and southern Wabash and Huntington counties, the output of which was piped to the cities of Wabash, Marion and Huntington. In the old field the supply of gas is practically exhausted, except for domestic consumption in the residences of the smaller towns and country. A few factories still use it in the summer season, but almost all have to supplement its use with coal or other fuel.

A short paper by W. M. Mills on the physiography of the region immediately surrounding Winona Lake, the famous resort in Kosciusko County, follows that of Mr. Kinney. In it interesting facts are given concerning the basin and water supply of the lake, together with others relating to the plant life found about its margins and in its waters.

Following the custom adopted in recent years of publishing in the reports a paper on the Natural History or Paleontology of the State, the next paper is devoted to the fossil faunas of the Niagara rocks of northern Indiana. This paper is by Dr. E. M. Kindle, and is a companion to his excellent paper on the Devonian fossils which formed a portion of the 1900 (25th) Report. Most of the species described in the paper are figured on accompanying plates, the drawings being made especially for the paper by Dr. J. C. McConnell, of Washington, D. C., the well known draughtsman of the Paleontological Division of the U. S. Geological Survey, and by G. S. Barkentin, who fills a similar position on the New York Survey. A number of the species described and figured are new to science; thus making the paper the more interesting to paleontologists and to all persons who desire some knowledge of the animals existing in the seas of Upper Silurian time.

The present volume is the 28th in the series of annual reports issued by the Department of Geology of the State of Indiana, and the ninth issued under the auspices of the writer. Believing that a general table of contents and index to the past volumes would be of permanent value to all persons who use these reports for reference, the writer has had one compiled by Dr. Hopkins, and it comprises the final paper of the present volume.

# THE GEOLOGICAL MAP OF INDIANA.

By T. C. Hopkins.

## EXPLANATORY.

The large geological map that accompanies this report is a compilation of the stratigraphic work of the assistants of the Indiana Geological Survey since 1895, or since the present State Geologist, W. S. Blatchley, has been in office. Much of the area is shown in greater detail on larger scale maps accompanying the different annual reports, but portions of the State were surveyed especially for this map, and the results are here shown for the first time.

The drafting of the geographical base was done by the writer with some assistance from Mr. Chas. J. Clark, Civil Engineer. It is a compilation from many different sources. The primary base was the record of the government land survey as delineated on the township sheets in the land office in Indianapolis. These were corrected in the field for a large part of the State, but for the portion of the State not covered by some of the assistants on the survey, the data is mainly that from the old government survey with such additions as could be obtained from other sources, and will be lacking in the accuracy of detail found in the portions covered by the field work of the assistants on the survey.

The geologic work was done by the different assistants on the survey. Geo. H. Ashley supervised all the work on the Coal Measures, and did a considerable portion of it himself. He also, with Mr. Kindle, traced the partings for the Lower Carboniferous groups in southern Indiana south of and including part of Orange County. The Coal Measure maps are published in seven map sheets in the Twenty-third Annual Report, and the maps of the Lower Carboniferous limestone of southern Indiana are published in two sheets in the Twenty-seventh Annual Report.

C. E. Siebenthal traced the boundaries of the oölitic limestone in Lawrence, Monroe and southern Owen counties, as delineated on the sheets published in the Twenty-first Annual Report. He also assisted Mr. Ashley in mapping the Coal Measures as indicated in the Twenty-third Annual Report. He also mapped part of the Devonian area of southern Indiana as shown on the map sheet in the Twenty-fourth Annual Report.

E. M. Kindle mapped the whetstone area in Orange County, and assisted Mr. Ashley in mapping the Coal Measures and the Lower Carboniferous of southern Indiana, and did part of the areal work on the Silurian and Devonian in north-central Indiana.

August F. Foerste mapped the Silurian and Ordovician areas in the southeast part of the State and also placed the work on the State map. Part of this work is shown on sketch maps accompanying his papers in the Twenty-first and Twenty-second Annual Reports, but a considerable portion of it is shown on the State map for the first time.

J. F. Newsom, aided by his students from Indiana University, mapped a section across southern Indiana and traced a considerable portion of the partings on each side of the Knobstone group.

J. A. Price mapped the Waldron shale in eastern Indiana, as shown on the map sheets accompanying his paper on that subject in the Twenty-fourth Annual Report, and assisted Mr. Ashley in mapping the coal field.

The writer, T. C. Hopkins, mapped the base of the Coal Measures from township 12 N. to its northern limit, as shown on the map sheets in the Twentieth Annual Report. He also traced the partings between the different groups of the Lower Carboniferous through Lawrence, Monroe, Owen, Morgan, Putnam, Montgomery, Fountain and Tippecanoe counties as delineated on this map for the first time. He also traced part of the Knobstone parting, and did some work on the Devonian shales in Tippecanoe County.

All of the work was done under the direction and supervision of the present State Geologist, W. S. Blatchley.

The geological partings in the central and north-central portions of the State are deeply buried beneath a heavy mantle of glacial drift, so that very few outcrops of the rocks can be seen; hence the partings between the different groups could not be traced with the same degree of accuracy as could those in the western, south-

ern and southeastern parts of the State, where the glacial drift is absent or much thinner, and where the streams have eroded deep valleys, thus causing many outcrops of the rocks so that their position can be determined. The greater detail in these areas is indicated by the greater sinuosities of the lines of parting.

It may be of interest to the general reader to know how a geological map is made. It will not be possible in a few lines to give all the details of such work, but in general the plan is somewhat as follows: The geologist first traverses the region to be mapped, visiting the outcrops wherever he can find them, studying them in their different characters and noting their relations to each other, so that he can make out a section of the geological column showing the kinds of strata, that is the different limestones, sandstones, shales, etc., their relation to one another and the thickness of each as they occur in the area to be mapped. He then decides upon how many of these subdivisions he will show on the map he is to make. Thus sometimes each single stratum is shown by a separate color or pattern and again a series of strata are grouped together and delineated by a single color for the whole group.

After determining how many and what groups are to be represented, and knowing the general characteristics and distinctions of each, he proceeds to find where these different groups outcrop and to trace the lines of parting where the outcrops of the different groups meet. If the rocks were perfectly bare this would be a very simple process and would only necessitate the worker's ability to properly locate on the map the line as he follows it out in the field. But the outcrops are, in many places, in fact in Indiana in most places, covered with a thick mantle of loose material and only in places here and there on the bluffs of the watercourses and the steep places on the hillsides can the rock be seen. To trace out the line of parting where the outcrops can be seen only here and there requires the application of considerable general knowledge and close observation. It is necessary to study the character of the soil produced by the different strata which is sometimes so characteristic as to enable one to follow out the parting in this way. It is necessary to observe the topographic peculiarities of each stratum, which is an assistance sometimes. If one is a bed of clay or shale underlying a limestone or sandstone, it is frequently a horizon for springs. Frequently the only data avail-

able is that obtained from well records. In many regions some of the wells, in some places all of them, are sunk through the soil mantle into the solid rock underneath and if the geologist can obtain a piece of the rock or obtain definite information about it, he will be greatly aided in his work.

If every person who sinks a well or has one made would keep a careful record it would be a great service to geology. The most desirable data are the thickness of the soil mantle to the solid rock, the kind of rock first struck and thickness of this and of any other underlying strata that are penetrated by the well digger or the drill. If a careful record had been kept of all the wells that have been sunk in Indiana and these records were accessible to the geologist, they would be of great service.

When, by the aid of these different methods and others, the geologist has determined the position of the lines separating the outcrops of the different strata, he draws them on his map and designates the different areas by different colors or different shading or marking, and the engraver and the printer make a reproduction of it by engraving it on copper or stone and then printing from it as from ordinary type.

The time, the expense and the skill required in the construction of a geological map are increased as the scale of the map increases, and as greater accuracy of detail is required. If an area is underlain by valuable mineral deposits it may be studied and mapped on a scale and nicety of detail that would not be justified on another area.

No attempt has been made on the accompanying map to show the different kinds of soil and glacial deposits of the State, as sufficient data for that part of the work has not been gathered.

Many of the minor subdivisions are too small to be readily represented on a map of ordinary size. Hence the Geological map of Indiana presents the distribution chiefly of the major subdivisions of the Paleozoic formations of the State, while many of the smaller subdivisions are recorded only in the text.

A brief discussion of the chief characteristics of the various divisions and subdivisions of the Paleozoic rocks of Indiana is presented in the following pages.

# A SHORT DESCRIPTION OF THE TOPOGRAPHY OF INDIANA,

## And of the Rocks of the Different Geological Periods; to Accompany the Geological Map of the State.

By T. C. Hopkins.*

## TOPOGRAPHY OF INDIANA.†

The topography of Indiana is somewhat diversified. The northern part of the State is covered by the ice plains, which are characterized by many lakes and swamp areas, with sluggish streams and no deep valleys or high hills, the broad plain being diversified only by the inequalities of the glacial deposits. These features characterize, in the main, the northern third of the State.

The middle third is somewhat more diversified. The eastern half of it is a broad rolling plain area, with no prominent hills nor any very deep valleys. The streams in places run over the surface of the plain, and in places are slightly intrenched in it. In the western half of the middle third the streams are more deeply intrenched; the Wabash and some of its tributaries, as Sugar Creek, Pine Creek and others, have cut gorges 300 to 400 feet deep along parts of their courses. Some portions of White River and its tributaries are similarly intrenched.

The southern third or more of the State is much more diversified. The area is more deeply trenched by the streams; so much so in places that lower secondary plains have been formed, and the underlying rocks have stamped their character on the surface. As the strata have a low west and southwest dip, the more durable rocks form cuestas or sloping plateaus, with steep escarpments to the east on their outcropping edges, and long plains gently sloping towards the west on the bedded surface. Between these escarpments are irregular plain areas on the softer strata. New-

*The part on the Ordovician and the Silurian was written by A. F. Foerste, as indicated.

†The topography of southern Indiana is discussed by J. F. Newsom in the 26th Annual Report, p. 238, and in the Journal of Geology, Vol. VI, pp. 250-257; by F. Leverett in the 18th Annual Report U. S. Geol. Surv., Pt. IV, pp. 429-431, and by G. H. Ashley in the 27th Annual Report, p. 53.

som cites three of these cuestas and three lowland areas, the broadest one of which is on the west on the outcrop of the Coal Measures strata.

The upland sloping plateaus are in many places very much dissected and diversified by the numerous deep valleys cut in them, so that they form a mass of irregular hills. The area in most places along the outcrop of the Mansfield sandstone is very much broken, and along the eastern margin of the outcrop, where the sandstone caps the hills, the latter are high, steep and marked by many perpendicular cliffs and steep talus slopes. This belt of cliffs and gorges is markedly different from the Knobstone area further east which extends through Brown, Monroe, Scott, Lawrence, Jackson, Washington, Clark and Floyd counties. As the name indicates, the hills here are knobs or rounded hills, frequently high and steep but generally free from the perpendicular and overhanging cliffs which characterize the Mansfield sandstone plateau and the limestone plateaus. The highest part of the State is in the vicinity of the "Summit," in Randolph County, about 1,285 feet above sea level. The next highest portion is thought to be the Knob district in Brown County, on the divide between the White and the Ohio rivers. The lowest part of the State is in the southwest part, at the junction of the Wabash and the Ohio rivers. There is very little flood-plain area along the Ohio River in Indiana. It is flanked by the deeply dissected border of the upland plain through which it has cut its deep valley.

The broad outcrop of the Mitchell limestone shown on the map, extending from the northwest central portion of the State, east of south to the Ohio River, is characterized best as possessing a sinkhole topography. It is a very cavernous region, and the openings from the surface into the caverns are basin-like or funnel-shaped depressions known as sink-holes. The many scores of these sinkholes give the area quite a pockmarked appearance.*

## THE GEOLOGICAL HISTORY OF INDIANA.

Geological time is divided primarily into four eras—Azoic, Paleozoic, Mesozoic and Cenozoic, to which some writers add a fifth, Psychozoic, and some insert another (Proterozoic) between the first two. These primary divisions are divided and subdivided

*The details of the topography of the area are given in the papers of Newsom and Ashley, already referred to.

into different periods, epochs, and stages, the terms, groups, systems, series and formation are the corresponding terms applied to the rock formations. This terminology, however, is not closely adhered to by many writers.

The record that has been preserved of the events of geological time is that found in the rocky strata which are literally the leaves of the geological history. At no one point are all these leaves preserved, so that the history recorded in the strata at any one point is only a portion of the whole, and to get a complete geological history it is necessary to combine the fragments obtained from the different localities in the world.

In Indiana there is no accessible record of Azoic rocks, none of the Mesozoic, and only a very short part of Cenozoic, which limits the strata practically to the Paleozoic, and not all of that is represented. The relation of the time represented in the rock strata in Indiana to all geological time is shown in the accompanying table:

GEOLOGICAL TABLE.

| *Eras.* | *Periods.* | *Correlation.* | | |
|---|---|---|---|---|
| | | INDIANA. | PENNSYLVANIA AND NEW YORK. | MISSISSIPPI VALLEY. |
| Cenozoic. | Quaternary-Pleistocene | Recent. | | |
| | | Glacial. | | |
| | Tertiary. | | | |
| Mesozoic. | Cretaceous. | | | |
| | Jurassic. | | | |
| | Triassic. | | | |
| Paleozoic | Permo-Carboniferous | Merom Sandstone | Upper Barren. | |
| | | Productive coal measures | Upper Productive. | |
| | | | Lower Barren. | |
| | | | Lower Productive. | |
| | | Mansfield Sandstone | Pottsville Conglomerate | Millstone Grit. |
| | Mississippian or Lower Carboniferous | Huron | | Chester-Kaskaskia. |
| | | Mitchell | | St. Louis. |
| | | Bedford öolitic. | Mauch Chunk | Warsaw. |
| | | Harrodsburg | | Burlington. |
| | | Knobstone | | Keokuk. |
| | | Goniatite | | Chouteau. |
| | Devonian | New Albany | Genessee. | |
| | | Sellersburg | Hamilton. | |
| | | Silver Creek | | |
| | | Jeffersonville | Corniferous. | |
| | | Pendleton | Schoharie. | |
| | Silurian (Upper Silurian) | Water Lime | Lower Helderburg(?) Salina. | |
| | | Louisville | Niagara. | |
| | | Waldron | | |
| | | Laurel | | |
| | | O-good | | |
| | | Clinton. | | |
| | Ordovician (Lower Silurian) | Richmond | Hudson River. (Cincinnati.) | |
| | | Lorraine | | |
| | | Utica. | | |
| | | Trenton. | | |
| | | St. Peter's(?) | Chazy. | |
| | | Lower Magnesian(?) | Calciferous. | |
| | Cambrian | Potsdam(?). | | |
| Azoic | Algonkian(?) | | Huronian. | |
| | Archean | | Laurentian. | |

General Features.—The area covered by the State of Indiana has a varied and interesting geological history. During that long Azoic era, that beginning period of which the record is so indefinite, we have little knowledge of what was taking place in Indiana. At some time during that period there was an elevation of the land in the north through Canada, the Adirondack mountains were elevated, and extensive land areas were formed along the eastern United States, extending in places farther out into the Atlantic ocean than the present shore line. There was a land area to the northwest in Wisconsin, one in Missouri, and different land areas along the Rocky mountains and the Pacific coast area.

Sometime previous to the Paleozoic era the central portion of this interior sea became a low land area. A land area, because there are no Lower Cambrian sediments, and probably a low land area near sea level, because there is no evidence of great erosion during the interval. Towards the close of the Middle Cambrian period, this interior land area began to subside and the sea covered all the Mississippi valley area except the few small Azoic areas mentioned above.

During the Ordovician period the Indiana area probably remained beneath the sea. A portion of the time, it was a clear, open sea, in which shell fish, crinoids and corals flourished. Part of the time the seas were muddy with the sediments carried in by the streams and stirred up by the waves. About the close of the Ordovician period there appears to have been an island covering an indefinite area around Cincinnati formed in this great sea, but probably it was not lifted far above the sea. During the Silurian and Devonian periods the area now included in Indiana was probably under the sea the greater part of the time, except possibly a small area in the southeast part of the State. In the Lower Carboniferous period the southwest part of Indiana was covered much of the time by an open sea, in which lived great numbers of lime-secreting organisms that built up the great limestone strata of that age. During the Lower Carboniferous period there was an elevation of the northern part of the State above the sea level. This land area gradually extended southward by the recession of the sea so that each succeeding stratum was shortened at the northern end.

At the close of the Lower Carboniferous period there was a depression of the land, and the incoming beach formed a heavy bed

of sandstone and conglomerate over the southwest part of the State. On this bed of sand (the Mansfield sandstone) the coal beds were deposited during the long Carboniferous period. During part of the time the area, or the greater part of it, would be above sea level and covered with swamps and bogs in which the vegetation accumulated to form the coal beds, and part of the time the area would be depressed below sea level, when the limestones and sandstones would be formed. This fluctuation continued throughout the Carboniferous period, while the coals, clays, sandstones and limestones of that period were being deposited.

At the close of the Carboniferous period the land was elevated above sea level, an uplift which included almost the entire Mississippi Valley, except a small area in southwestern Indiana and Illinois, and part of Kansas, where the sea possibly remained during at least a portion of the Permian. The recession of the sea from Indiana territory during the Permian, left it a land area above tide level, and in this condition it has ever since remained.

But little record is left in Indiana of the long Mesozoic and Cenozoic eras until the Pleistocene period near the close of the Cenozoic, when the land was submerged beneath a great sea of glacial ice.

The different deposits that were formed on the Indiana area during these long geological ages are shown on the accompanying table and described briefly in the pages following.

## DESCRIPTION OF THE ROCKS FORMED IN THE DIFFERENT GEOLOGICAL PERIODS IN INDIANA.

The different limestone, sandstone, shale, clay and coal strata have been described in great detail in the preceding 27 volumes of the publications of the Indiana Geological Survey. It has been, however, thought advisable to give a brief connected description or synopsis of the different periods here, as many persons interested in the geology of the State may not have opportunity to consult all the different reports. This description must necessarily be brief, and persons interested in the details of any particular group or area will note the references to the more extended papers in the different volumes.

There is no outcrop of any strata in Indiana older than the Cambrian, but at many other points in the world such strata occur.

The oldest stratified rocks have been called *Azoic* because they contain no life remains. They have also been named *Archean*, meaning ancient. Some writers have divided and subdivided them into the Archean below and Algonkian above, the latter group subdivided into Lower and Upper Huronian and Keweenawan. Presumably, sediments of this very long and ancient period underlie all or part of Indiana, but their presence is not known. We can not be certain whether Indiana was a land or sea area during this period.

The record of Cambrian time in Indiana is not much clearer than the Azoic. It is thought from indications in neighboring States that the central and north-central portions of the United States was a land area during early Cambrian and possibly part of Azoic time. This land was elevated but little above sea level, so that very little erosion took place, and no geographic change of any kind is recorded until towards the end of the Cambrian, when there was a depression of the area, an inflow of the sea and the formation of sediments of Middle and Upper Cambrian age.

The upper division of the Cambrian in New York is a hard quartzitic sandstone, known as the Potsdam sandstone, and this is thought to extend westward across Ohio, Indiana, Illinois, Michigan, Wisconsin and Minnesota. It is one of the widespread sandstone formations of the United States. It does not outcrop in Indiana, but it is supposed to have been penetrated by the deep borings in northern Indiana at Hammond, Crown Point and Laporte, and possibly underlies at great depths all the State.

The Ordovician or Lower Silurian period is divided in New York into the (1) *Calciferous* (Beekmantown), a grayish limestone, often arenaceous, frequently cherty, usually magnesian and rarely fossiliferous. It is probably the equivalent of the *Lower Magnesian limestone* of Missouri and Wisconsin. It does not outcrop in Indiana, but is thought to have been penetrated by the drill in several deep borings. In the deep boring at Bloomington, the last 50 feet is thought to be Lower Magnesian limestone.

(2) The *Chazy* limestone in eastern New York is gray to black in color, furnishing black marble in places. It is thought to be the equivalent of the *St. Peter's sandstone* of Wisconsin and adjoining States. It does not outcrop in Indiana, but has been penetrated by the drill in a number of deep borings. It is an excellent

water-bearing stratum and is the source of the water in a number of artesian wells. The water is generally salt and frequently called "Blue Lick" water. It contains some magnesia and hydrogen sulphide, which, with the sodium salts renders it undesirable for household purposes. In places it is used quite extensively for its curative properties. The thickness of this rock in Indiana is not definitely known owing to the uncertainty of the drill records at such great depths. The following depths below the surface are recorded: Portland, 1,600 feet; Union City, 1,680 feet, and 600 feet below sea level; Muncie, 1,382 feet, 450 feet below sea level; Rockville, 2,600 feet; Goshen, 2,350 feet.

While it is commonly classed as sandstone by the drillers in Indiana, it is quite calcareous in many places, and is more properly a siliceous limestone. At Connersville, Bloomington and Edinburg there is a bed of black shale, respectively 25, 40 and 83 feet thick, lying on top of the calcareous St. Peters' sandstone and underneath the Trenton. It is uncertain to which of the groups it belongs.

## ORDOVICIAN.

(By A. F. Foerste.)

The Ordovician or Blue limestone strata occupy the greater part of the area east of a line connecting Richmond, Cambridge City, Connersville, Laurel, New Point, Osgood, Versailles, Cross Plains, Canaan, and Madison, in the southern corner of Indiana. It is exposed along various streams in southern Decatur, western Ripley, and eastern Jennings counties, in areas otherwise occupied by the Silurian. Along the Ohio River it may be traced as far south as Charlestown Landing in Clark County.

The Ordovician consists chiefly of blue clay; with this is interbedded a variable quantity of limestone. The clay is usually soft and plastic. Owing to the presence of calcareous and siliceous constituents it may be indurated into a clay rock or a thin bedded sandy shale. The limestone occurs in the form of thin layers, usually not exceeding 6 inches, and often less than 3 inches in thickness. The layers are often hard. Many show their organic origin by the presence of fossils. Some are distinctly crinoidal. Others consist chiefly of brachiopoda or bryozoa cemented together by a mass of calcareous sediment.

Fossils frequently are abundant and very well preserved. The Ordovician exposures of southeastern Indiana form some of the best collecting grounds in the Central States.

The Ordovician of Indiana includes the top of the Trenton and all of the Cincinnatian formations.

### The Trenton.

The Trenton forms a narrow strip along the Ohio River between the southeastern corner of Ohio County and Markland, near the middle of the southern boundary of Switzerland County. Lithologically it resembles very much the remainder of the Ordovician section in Indiana. The lower part of the Trenton exposures consists of a peculiar bluish argillaceous limestone, which can be easily distinguished from most limestones in the Cincinnatian formations when once it becomes familiar. Otherwise it can be recognized only by means of its fossil contents. By drillers for oil and gas in southern Indiana it is classed with the Cincinnatian formations. The Trenton of these drillers occupies a considerably lower horizon.

### The Cincinnatian Series.

The rocks of this series are often called the Hudson River rocks. However, recent studies of the rocks of the Hudson River Valley have shown that the so-called Hudson River rocks do not form a distinct formation in the sense in which this name was applied at first, so that the term Cincinnatian is preferable for the mass of Ordovician rocks overlying the Trenton.

The Cincinnatian series of rocks of Indiana are divided into three main subdivisions or stages, called in ascending order, the Utica, Lorraine, and Richmond stages.

### The Utica Formation.

The thickness of the Utica formations is about 260 feet. The lower half consists chiefly of clay, with relatively few layers of limestone. In the upper half, limestone forms about one fifth of the section. In Indiana, the Utica may appropriately be called the *Dalmanella multisecta* zone. While the range of this fossil extends into the lower part of the Lorraine it is nowhere so com-

mon at these upper horizons as in the Utica. In fact, in Indiana *Dalmanella* is usually very rare or absent in the lower parts of the Lorraine. In Ohio, the Utica is divided into three beds—the Lower Utica, 80 feet thick; the Middle Utica, 120 feet thick; and the Upper Utica, 60 feet thick.

### The Lorraine Formation.

The thickness of the Lorraine formations in Indiana is about 260 feet.

The lower third of the Lorraine, about 90 feet thick, equivalent to the Mount Hope-Fairmount beds, includes a considerable amount of yellowish, sandy, clayey rock which weathers to a sandy shale or clay. The limestones are usually thin, one or two inches in thickness, occasionally 3 or 4 inches, and are rarely suitable even for cellar stone. Clay forms by far the greater part of the section. This may be called the *Plectorthis* zone. *Plectorthis plicatella* and the varieties varying towards *Plectorthis triplicatella* are common and range from the base to the top of this part of the Lorraine section, although not found in equal abundance at all localities nor at all horizons. *Plectorthis dichotoma* is most common at this horizon, but occasional specimens are found even as far as the top of the Bellevue bed. Near the Ohio line, *Dalmanella meeki* is a common species, *Strophomena planoconvexa* is a form characteristic of this part of the section. It occurs between 3 and 8 feet above the base, and also again between 33 and 38 feet below the top.

The following division of the Lorraine, the Bellevue bed, has a thickness of at least 20 feet. At some localities it may reach 25 feet. It is usually a coarse rubble limestone, but at some localities the lower part of the bed consists of coarse-grained massive limestone, the middle of rubble limestone, and the upper part chiefly of clay. The most characteristic fossils are *Monticulipora molesta* and *Nicholsonella vaupeli*, but in southern Indiana it may be called the *Platystrophia lynx* zone. While *Pl. lynx* occurs also in the Corryville and Mount Auburn beds, in southern Indiana it is abundant only in the Bellevue bed. *Rafinesquina alternata-nasuta* occurs in the upper half of the Bellevue bed and extends into the Corryville.

The upper half of the Lorraine is formed by the Corryville, Mount Auburn, and Warren beds, having a total thickness of about 130 or 135 feet. Clays predominate greatly. The limestones are usually thin, rarely coarse-grained, with the fossils confined chiefly to the upper and lower surfaces of the layers. The limestones often weather to a yellowish sandy rock. The upper half of the Lorraine might be called the *Rafinesquina alternata* zone; not because this fossil is confined to this zone, for it ranges throughout the Ordovician; nor because it is more abundant at this horizon than at others, for this is not the case; but because it is the most conspicuous of the few species of brachiopods commonly found at this horizon. It is flat and large, often adheres to the surfaces of the slabs of limestone which cover the slopes of the hills at this horizon, and thus becomes conspicuous. *Platystrophia laticostata* and its varieties are more commonly found in the clays. *Zygospira modesta* is not a conspicuous fossil. Other species of brachiopods do not occur in abundance.

The Corryville bed has a thickness of 45 to 50 feet, the Mount Auburn of about 20 feet, and the Warren of 60 to 70 feet. In many parts of Ohio the Mount Auburn bed is the zone in which *Platystrophia lynx* is preëminent. In Indiana, however, it is never very abundant at this horizon, although at some localities it occurs in sufficient numbers to form a distinct upper *Pl. lynx* zone. *Coelociema oweni* extends from the Mount Auburn into the lower part of the Warren bed.

In the Warren bed the limestones often are distinctly more clayey than in the Mount Auburn and Corryville beds. At the top of the Warren bed there is a mass of indurated, irregular, nodular clay rock which is very characteristic of this horizon. The most characteristic brachiopod of this horizon is *Dinorthis retrorsa*. While this fossil occurs also in the Lower Richmond, it is common only at a very restricted horizon, varying from 33 to 40 feet below the top of the Warren bed in the eastern part of the State, to 47 feet below at Madison.

### The Richmond Formations.

The thickness of the Richmond varies from 280 feet in the southern part of Franklin County, to 177 feet at Madison, 112 feet at Marble Hill, and 75 feet east of Louisville.

The lower part of the Richmond stage is formed by the Waynesville bed. In Franklin and Dearborn counties it has a thickness of about 80 feet. Seven miles north of Madison its thickness is 70 feet. South of Madison its thickness diminishes rapidly, and before passing out of southern Indiana it is reduced to about 25 feet. In the greater part of the State the most characteristic brachiopod in the lower part of the Waynesville bed is *Dalmanella jugosa*, so that this part of the Waynesville bed may be called the *Dalmanella jugosa* zone. In Franklin County *D. jugosa* is found in the Warren bed, and even lower. It ranges into the lower part of the Liberty bed. But it is very abundant only in the Waynesville bed, and usually only in the lower part. Between Moore's Hill and Holman it is common up to 65 feet above the base of the Waynesville bed; south of Friendship, up to 40 feet; seven miles north of Madison, up to 30 feet; on Saluda creek the *D. jugosa* zone is reduced to only a few feet; and at Marble Hill, to a few inches. Farther southward it appears to be absent.

The Middle Richmond is formed by the Liberty and the Whitewater beds. In the southern part of Franklin County its thickness is at least 150 feet. Seven miles north of Madison this is reduced to 44 feet, and at the mouth of Bull Creek only 10 feet of fossiliferous rock can be assigned with confidence to the Middle Richmond.

At the type locality the thickness of the Liberty bed was estimated at about 35 feet. Its most characteristic fossil is *Hebertella insculpta*, which forms a distinct zone at its base. At the more northern localities the thickness of the *H. insculpta* zone is 7 feet; southward this diminishes slowly to 5 feet in the middle of Dearborn and Ripley counties, and then more rapidly to a foot and a half or less in the northern part of Switzerland and Jefferson counties. At Madison, specimens are very rare and appear to come from the base of the *Dinorthis subquadrata* zone.

In the northern part of the Ordovician area of Indiana the middle and upper part of the Liberty bed and almost all of the Whitewater bed may be called the *Dinorthis subquadrata* zone. Northward the base of the *Dinorthis subquadrata* zone is separated from the top of the *Hebertella insculpta* zone by an interval of 10 feet. In most of Dearborn and Ripley counties, and in the northern part of Switzerland this interval does not exceed 5 feet.

Farther southward the interval diminishes until near Madison the zones are separated by an interval not exceeding 2 feet. The thickness of the *Dinorthis subquadrata* zone is 140 feet at the more northern exposures. At the most southern exposures of the Richmond the known vertical range of this species is reduced to a few feet, or even inches.

The upper part of the Waynesville bed, and all of the Middle Richmond, is characterized by the presence of numerous specimens of various species of *Strophomena*. In the upper part of the Waynesville bed and in the Liberty bed, *Strophomena planumbona* preponderates. In the Whitewater bed *Strophomena vetusta* preponderates. *Strophomena neglecta* is confined to the upper third of the Waynesville bed. *Strophomena nutans* is found at various levels in this bed. In the *Dalmanella jugosa* zone, *Strophomena* is usually not common or is even rare. *Rhynchotrema capax* is common in the upper part of the Waynesville bed and in the Middle Richmond.

In the lower part of the Waynesville bed clay forms most of the section, but well-bedded limestones, 2 to 4 inches in thickness are rather common, especially near the base of the *Dalmanella jugosa* zone. Near the upper part of the Waynesville bed the relative quantity of clay increases and the limestone layers are thinner. The lower part of the Liberty bed, the *Hebertella insculpta* zone is often a limestone rubble. The remainder of the Liberty bed consists of clay and even bedded limestones averaging 3 inches in thickness. In the Whitewater bed the strata often present a roughish, concretionary, nodular appearance. The limestone layers are seldom over 2 inches thick.

The Madison bed in the northern part of the Ordovician area of Indiana consists of clay and clay rock. In Jefferson County all except the base of the section is usually indurated into a massive, homogeneous, argillaceous, brownish limestone, which disintegrates readily under the influences of weathering. In all the more southern exposures the greater part of the section is practically unfossiliferous. At the base of the Madison bed in parts of Ripley and Jefferson counties, there is a bed containing *Columnaria alveolata*, *C. halli*, and *Calopoecia cribriformis; Tetradium minus* occurs at this horizon or immediately above. It may be known as the coral zone.

The Ordovician rocks of Indiana are of little value commercially. The limestones are of little use except for cellar stones. Recently they have been employed to a great extent for road metal in the southeastern corner of the State, within the area underlaid by Ordovician rocks.

## THE SILURIAN OF SOUTHEASTERN INDIANA.

(By A. F. Foerste.)

The western boundary of the Silurian or White limestones of southeastern Indiana may be indicated approximately by a line connecting Newcastle, Rushville, Greensburg, Westport, and Madison. From Madison the Silurian extends down the river as far as Louisville. West of this boundary the Silurian is exposed along the valleys of a number of streams traversing the Devonian areas of Rush, Shelby, Decatur, Bartholomew, Jennings, Jefferson, and Clark counties.

In the former reports of this survey, the writer suggested the following classification for the Silurian rocks of southeastern Indiana, the divisions being named in descending order:

Louisville limestone.
Waldron clay.
Laurel limestone.
Osgood clay and limestone.
Clinton limestone.

### The Clinton Limestone.

The Clinton of southeastern Indiana is a detrital limestone. At the more northern areas it is distinctly crinoidal and contains numerous small rolled fragments of bryozoa and of various shells. Fossils are quite abundant in this detrital phase of the Clinton. However, they are usually enclosed within the rock and are secured chiefly by breaking it open. In Ohio the top of the Clinton is clayey, and here fossils are often better preserved.

Southward, in the northwestern part of Switzerland County, and in many parts of Jefferson and Clark counties, the Clinton limestone is often very dense, hard, and siliceous, and contains comparatively few fossils, although detrital, fossiliferous phases also are known.

In Wayne County, the Clinton usually is a coarse detrital limestone, having a white, gray, or light red color. In the western part of Fayette County the Clinton is of medium grain, and the color more often is blue, becoming rusty brown on weathering. In Franklin and Ripley counties the limestone is distinctly detrital, often rather coarse-grained, usually fossiliferous, and has a characteristic salmon brown color. These salmon brown phases of the Clinton are seen at various localities in Jefferson and Clark counties, continuing into northern Kentucky.

In the southwestern part of Preble County, Ohio, about six miles east of College Corner, Indiana, the Clinton has a thickness of at least 9 feet. Southeast of Richmond, on Elkhorn Creek, its thickness is 11.5 feet. Southward, in Decatur County, the thickness usually varies between 4 and 6 or 7 feet. In the more southern counties it rarely exceeds 4 or 5 feet, and often is reduced to 1 or 2 feet.

In the western part of Ripley County and in the adjacent parts of Decatur and Jennings counties, the Clinton is absent. Here one or two islands appear to have existed during the deposition of the Clinton. In the lower part of the Clinton limestone bordering upon these islands, angular and rounded fragments of Ordovician rocks are enclosed within the Clinton. At some localities these fragments are common. Southward, in southern Ripley and in Jefferson counties, lenses of clay rock, varying from a few inches to a foot or two in width, are present in the Clinton; these also suggest shallow water conditions. For the hypothetical islands, the name Ripley Island or Islands is suggested. Only the eastern boundary is known.

The genera *Illaenus*, *Cyphaspis,* and *Encrinurus* are not represented in the Cincinnatian strata of Indiana but reappear in the Clinton. Here the genera *Phacops* and *Deiphon* make their first appearance. *Glyptoceras* is known only from the Clinton. *Subulites* is absent in the Cincinnatian but reappears in the Clinton. *Platyostoma* makes its first appearance in the Clinton. The species described as *Paleopupa abrupta* is probably closely related to the genus *Onychochilus;* at any rate it is not related to *Pupa* or any other land shell. Among the brachiopoda, *Strophonella, Rhipidomella*, *Whitfieldella*, *Atrypa* and *Stricklandinia* here make their first appearance. While *Triplecia* is absent in the Cincin-

natian, it reappears in the Clinton. This is true apparently also of *Orthis*. The form identified as *Strophomena patenta* in the Clinton of Ohio is not even closely related to the type from New York; the name *Strophonella filistriata* is here suggested for the Ohio specimens. The absence of *Pentamerus* is of special interest, since *Pentamerus oblongus* is considered one of the most characteristic fossils of the Clinton in New York. Nor has *Atrypa reticularis* or any species of *Cyrtia* or *Spirifer* been found so far.

### The Osgood Bed.

The base of the Osgood section is formed by several thin layers of limestone having a total thickness of 8 to 15 inches. Above this lies the lower Osgood clay, the most important part of the section, from 11 to 16 feet thick. In Kentucky this clay is usually soft. In Indiana it is often more or less indurated or converted into a clay rock. This is true especially of the upper layers in the more northern parts of Jefferson County and in the adjacent parts of Ripley. In the central parts of Ripley and Jennings counties the upper part of the lower Osgood clay is changed gradually to a rubble limestone, and the entire bed is quarried as an inferior grade of limestone at New Point.

At the Derbyshire falls, southwest of Laurel, less than two feet of rock can be identified as the lower Osgood clay. The section is instructive. The greater part of the Clinton, for a distance of 7 feet above the base, consists of a bluish, irregular, bedded rock, near the upper part of the falls. The remainder of the Clinton section, 1 foot 9 inches thick, has a salmon brown color at the base but is white and fine grained at the top. The greater part of the Osgood section is represented by white well-bedded limestone, the upper layers of which are quarried. In Ohio these layers are known as the Dayton limestone. They evidently represent the lower part of the lower Osgood clay in addition to the limestone usually found at the base of this clay. They maintain their character as limestones also in Fayette and Wayne counties, sometimes closely resembling the Dayton limestone. At the Derbyshire falls, immediately above this limestone, there is a layer of clay, 1 foot 9 inches thick, also referred to the Osgood section. Overlying this are well-bedded white limestones, 6 feet thick,

without chert, forming the valuable quarry rock, and also cherty layers.

In the more southern parts of the State, the lower Osgood clay is overlaid by coarse-grained, often crinoidal limestone. In Clark County this rock is often siliceous and has weathered to a brownish color. Its thickness in this county often equals 5 feet. In the central and northern parts of Jefferson County it is usually a whitish crinoidal limestone, varying between 3 and 4 feet in thickness. In Ripley and Jennings counties it is still a white detrital limestone, not exceeding 3 feet in thickness and sometimes equaling only 15 inches. Farther north it can not be identified with certainty, owing to the alteration of the clayey part of the Osgood section to an inferior quality of limestone.

Overlying the limestone, and forming the top of the Osgood section in Clark, Jefferson and Ripley counties, is the upper Osgood clay, varying from 3 to 5 feet in thickness at the more southern localities, but usually about 1 foot in thickness in the northern part of Ripley County. In Franklin County, the white limestones at the base of the Laurel section are underlaid by a layer of indurated clay rock, usually varying between 1 and 2 feet in thickness. It is not known whether this clay rock is equivalent to the top of the lower Osgood clay or represents the upper Osgood clay of more southern exposures.

In Indiana, *Pisocrinus*, *Stephanocrinus*, *Holocystites*, *Rhynchotreta*, *Spirifer*, *Cyrtia*, and *Nucleospira* make their first appearance in the Osgood bed, especially in the limestones and clay partings between the lower and upper Osgood clays. *Holocystites* is represented by numerous species although the published list may include many duplicates. In fact, in Jefferson and Ripley counties *Holocystites* may be said to characterize the Osgood, although the number of individual specimens found at any one locality usually is very small, even after long continued search. A variety of *Pentamerous oblongus,* but not the typical form, has been found in the Dayton limestone, an equivalent of the lower part of the Osgood bed, in Ohio. In Indiana, however, *Pentamerus* is unknown in the Osgood bed. Moreover, *Strophcodonta profunda, Illaenus ioxus, Ceraurus insignis,* and *Homolanotus delphinocephalus* have not been found as yet in the Osgood bed. In many respects the Osgood fauna is a forerunner of that

found in the Waldron. It corresponds to the reef fauna at the top of the Clinton of New York, where it occurs in the limestones exposed in the lens-like cross-sections just beneath the Rochester shale.

### The Laurel Limestone.

Above the Osgood bed is a series of limestones, usually well bedded, called the Laurel bed or Laurel limestone. Its thickness varies usually between 40 and 45 feet. At St. Paul in the northwestern part of Decatur county, its thickness is about 48 feet. Farther north its thickness has not been determined with accuracy.

Usually, it is a very white, hard limestone, occurring in even, well-bedded layers. These vary from 4 to 16 inches in thickness, and may be cut into slabs of almost any desirable dimension. In Indiana, it is quarried in Wayne, Fayette, Franklin, Rush, Decatur, Jennings, and Ripley counties. Southward, in Jefferson County, the limestone deteriorates rapidly in quality. The rock is less pure, becomes softer, more argillaceous, and does not form slabs of equally large dimensions. In Clark County, the rock becomes still softer and more argillaceous. Its color changes to brown and usually the rock does not withstand weathering. At some localities, a few of the layers furnish a good building rock while the greater part of the section is of inferior quality. Chert frequently is present, especially in the middle part of the section, 5 or more feet above the base of the Laurel. However, at many localities the layers which are free from chert are readily accessible and are quarried with profit.

Comparatively little is known as yet about the fauna of the Laurel limestone. That the fauna is quite large is shown by the great number of crinoids found at a single locality, St. Paul. The rock is usually very dense, and fossils are exposed only where the rock has been subjected for centuries to weathering. The weathered surfaces show great numbers of fragments of crinoid stems, and occasional crinoid bodies, but other fossils are found also. So far, however, they have received very little attention. As far as may be determined from a hasty examination of specimens in the field, the Laurel fauna shows close affinities with that seen in the Louisville bed, while the Waldron fauna is a

recurrence and farther development of that occurring in the Osgood bed.

### The Waldron Clay.

The Waldron clay forms a distinct bed overlying the Laurel limestone. In some parts of southern Indiana, and thence southward as far as central Kentucky, a clayey section often occurs in the lower part of the Laurel limestone, but it is usually less than two feet thick and does not contain the typical Waldron fauna. At the more southern localities the thickness of the Waldron clay varies usually between 4 and 10 feet, although locally it may equal 14 or even 20 feet. Northward, the thickness does not exceed 6 feet, and occasionally is reduced to 1 foot. So far it has not been traced north of Milroy, in the southern part of Rush county. Farther northward the clay gives way to limestone, but it is likely that when the Silurian faunas of the more northern areas become better known, it will be possible to follow the horizon of the Waldron fauna much farther north than it is known at present.

### The Louisville Limestone.

The Louisville limestone at Louisville has a thickness of more than 55 feet. The total thickness is unknown, since the base of the Louisville bed is not exposed at this point. At Charlestown Landing, its thickness is 57 feet. At Hanover its thickness does not exceed 30 or 35 feet. At Paris Crossing it does not exceed 25 feet. At Vernon it does not exceed 10 feet. East of Greensburg, on Sand Creek, it appears to be absent.

West of Greensburg, in the eastern part of Shelby and Bartholomew counties and in the adjacent parts of Rush and Decatur counties, a series of limestones, at some places eight feet thick, overlying the Waldron clay, is correlated with the Louisville bed.

The Louisville limestone thins out from Louisville in a northward and eastward direction. Judging from exposures in Kentucky this thinning increases from the flanks toward the crest of the Cincinnati anticline, in other words in an easterly direction.

The Louisville limestone is overlaid unconformably by the Devonian limestone. This is true also south of Louisville, at least as far as the central part of Kentucky.

At Louisville, in Kentucky, and at Utica and Charlestown Landing, in Indiana, the Louisville limestone is quarried to a considerable extent for lime. At Louisville it is used also as a building rock.

## THE SILURIAN OF NORTHERN INDIANA.

(By A. F. Foerste.)

Clarke and Schuchert have recently, 1899, proposed to divide the Silurian rocks of New York into three groups, in descending order:

Silurian { Cayugan. / Niagaran. / Oswegan.

The Oswegan includes the Oneida and Medina. It is not exposed at any point in Indiana, Ohio, or Kentucky.

The Niagaran of New York includes various horizons; in ascending order, the Clinton, Rochester, Lockport, and Guelph. In southern Indiana, it includes the Clinton, Osgood, Laurel, Waldron, and Louisville. In northern Indiana only the uppermost horizon, the Louisville, is exposed.

The Cayugan of New York corresponds in a general way with the rocks formerly known as the Lower Helderberg. In Indiana it has been identified only in the northern part of the State. It is represented by the Waterlime at Kokomo.

### The Kokomo (Waterlime) Limestone.

In Indiana, the Waterlime division of the Cayugan, has been definitely identified at only one locality. While it may be present also elsewhere along the flanks of the Indiana extension of the Cincinnati geanticline, it has been identified by means of its fossils only at Kokomo. Only a few species are known: *Eurypterus lacustris, E. kokomoensis, Carcinosoma newlini, C. ingens, Wilsonia kokomoensis,* and *Conchidium.* These fossils suggest the equivalence of the Kokomo limestone to the Bertie or Lower Waterlime bed, in the lower part of the Cayugan.

### The Niagaran Limestones of Northern Indiana.

The Niagaran area of northern Indiana contains comparatively few exposures of rock. Glacial deposits cover most of this terri-

tory, forming a mantle varying usually between 50 and 200 feet in thickness. Exposures of Niagaran rock are confined chiefly to the beds of the larger streams, and even here they are usually too widely separated and display too short a vertical section to make easy the determination of the stratigraphical relationship between the different exposures.

Moreover, the evidence of the relative stratigraphic position of the different exposures which might be furnished by the fossils is at present in too chaotic a condition to admit of many satisfactory conclusions.

None of the lists of fossils so far published from any part of northern Indiana give any evidence of the presence of the Clinton, Osgood, Laurel, or Waldron beds. *Pisocrinus benedicti, P. campana,* and *P. gorbyi* are known in Tennessee only from horizons above the Waldron, and *P. gemmiformis* either has a considerable vertical range or the name as used at present includes several species restricted to different horizons. Considering the difficulty of determining accurately the various species of bryozoa without the assistance of microscopical sections and well preserved exteriors, the Waldron bed species listed from the Niagaran of Wabash County scarcely offer a reliable basis for the determination of horizons. *Bilobites biloba* is more common in strata above the Waldron bed than at the Waldron horizon, in Tennessee, and *Meristina maria* is represented in the upper beds by a closely related species. It is not safe to conclude from this that the Waldron and the upper part of the Laurel are absent in the northern half of Indiana. All that can be stated at present is that their presence can not be safely asserted on the basis of the evidence so far at hand. They may be present along some parts of the axis of that part of the Cincinnati geanticline which extends from Richmond across Logansport toward the northwestern corner of the State.

The evidence of the presence of the Louisville and overlying beds, however, is conclusive. The presence of these beds may be asserted in the case of each county from which an extended list of fossils is at hand.

The total thickness of the Niagaran beds in northern Indiana is considerable. Well sections made in connection with the explorations for oil and gas indicate a thickness of several hundred

feet. It seems safe to assume that the thickness of that part of the section which overlies the Waldron horizon equals at least 200 feet.

From this it is evident that the different exposures of Niagaran rock in northern Indiana, even if of more recent age than the Waldron bed, probably include widely different horizons.

In the absence of better data for determining the relative stratigraphic position of the different exposures, the following suggestions may be of service:

The Niagaran exposures nearest Kokomo, and those nearest any other exposures believed to be stratigraphically equivalent to the Kokomo or Lower Waterlime limestone, probably represent the highest horizons of the Niagaran exposed in the northern part of the State. Here, probably, should be placed the exposures of Niagaran rock seen in Carroll, Cass, Miami, and Hamilton counties. These exposures are characterized by the presence of various species of *Conchidium,* in addition to numerous other species frequently found in the upper part of the Louisville bed at Louisville, or at still higher horizons in Tennessee.

Those Niagaran exposures along the crest of the Cincinnati geanticline which are nearest to the northern border of the Ordovician area probably represent the lowest horizons of the Niagaran exposed in northern Indiana. Here probably should be placed the exposures in Randolph, Jay and Delaware counties. These exposures are characterized by the presence of *Pentamerus oblongus,* usually in considerable numbers, and the absence of *Conchidium.*

In other words, it appears possible to distinguish an upper horizon in which *Conchidium* is common from a lower horizon, in which *Pentamerus oblongus* is common. The exposures in Jasper County are referred to the upper or *Conchidium* horizon.

Between the exposures referred to, the upper horizons of the Niagaran and those believed to belong to the lowest Niagaran horizons exposed in northern Indiana must be others which occupy an intermediate position, or whose position can not be determined more definitely. Here are placed the exposures in Madison, Grant, and Wabash counties. The exposures in Huntington County may represent a slightly higher horizon lying along the northern flank of the Cincinnati geanticline.

Along sections transverse to the direction of the Cincinnati geanticline, the lowest horizons should be represented by exposures along the crest, and the highest by points most distant from this crest. All attempts to correlate the data upon this basis have proved of little value so far. Along the Wabash valley, at least, quaquaversal dips complicate the problem.

The records of drillers for oil and gas indicate a depression across the axis of the Cincinnati geanticline in Carroll and Cass counties. The Silurian rocks within these counties have all been referred to the Niagaran by recent investigators, while the Kokomo limestone appears to occur at a higher altitude toward the southwest of this depression. The precise relation of the Kokomo limestone to this depression and to the crest of the Cincinnati geanticline should be determined if possible.

## Economic Uses of Silurian Rocks of Northern Indiana.

The Niagaran limestones of northern Indiana are used for the manufacture of lime in almost every county in which they are exposed. The rock usually is a magnesian limestone and the lime produced is a slow setting lime. The rock is used also for building purposes. In the northwestern counties, in White and Jasper, the limestone often is cherty and its usefulness in consequence is diminished very much, but layers and exposures more or less free from chert are known also.

Siliceous and cherty phases are seen also in the central and eastern counties, as far as Jay. It is not uncommon to find the upper and weathered beds of a quarry presenting a siliceous and more or less porous or cavernous phase while the lower beds are more compact and more serviceable both for lime and for building rock. In some parts of Grant, Miami, and Jay counties some of the limestone courses are clayey and will not withstand direct exposure to weathering. However, the more valuable layers occur also. At some localities in Wabash County, the limestone is well bedded, the layers are thin and very serviceable for flagging. In Huntington County, layers 4 to 6 inches thick are frequent. In Wabash and other counties, layers from 1 to 2 feet thick are known.

At Macksville in Randolph County the limestone is soft, friable, coarse-grained, and is suitable only for lime. Near Ridgeville, the rock occurs in layers 2 to 4 inches thick, hardens on exposure, and is used for cellar walls.

No connected study of the economic value of the rocks of the Niagaran area of Northern Indiana has been attempted so far. The exposures usually are few and distant, but this scarcity of exposures increases the importance of the few in existence, since almost of necessity they become the most convenient source of lime and building rock over comparatively wide areas.

### The Silurian-Devonian Unconformity of Northern Indiana.

Mr. E. M. Kindle has shown the presence, in the Niagaran area of Northern Indiana, of numerous quaquaversal dips associated with the upbuilding of small domes. He has also shown that the tilting of the Niagaran rocks resulting in these dips must in many cases have preceded the deposition of the Devonian rocks, since the latter in a number of cases are distinctly unconformable to Niagaran limestones. Near Delphi, for instance, at one locality horizontal beds of Hamilton age lie unconformably over Niagaran limestones dipping at an angle of 45 degrees. Near by, the Hamilton beds are absent, but the New Albany shale rests almost directly on the Niagaran strata. Again, on the east side of the river below Georgetown, in Cass County, the Jeffersonville division of the Devonian limestone consists of horizontal beds resting on Niagaran limestones dipping at an angle of 6 to 18 degrees.

Near Bunker Hill, Pipe Creek Falls, Waverly, Keysport, Georgetown, and the mouth of Little Rock Creek, the Devonian limestone resting upon the Niagaran is identified as equivalent to the Jeffersonville or lower division of the Devonian limestone. Near the mouth of Keeps Creek, and near Delphi, the beds resting on the Niagaran are identified as the upper or Sellersburg division of the Devonian. The Devonian beds exposed in White County are also recognized as belonging to the Sellersburg division.

In the southern part of Madison County, near Pendleton, the Devonian rock resting on the Niagaran is the Pendleton sandstone, the equivalent of the Schoharie grit of New York.

The absence of any mention of distinct unconformity at most localities so far examined suggests that the Silurian-Devonian contact is not marked everywhere by strong unconformity, but that at many points in northern Indiana the unconformity is slight. In the southern part of the State the Silurian-Devonian contact is also accompanied by a slight unconformity. A distinct unconformity may be noticed at the William Avery quarry on Conn Creek, south of Waldron, and at the Mary Wurtz locality on the road to Geneva. (Twenty-second annual report, Indiana survey, pages 234 and 235.

The relationship of the Kokomo or lower waterlime limestone to this unconformity has not been determined. Judging from investigations in western Tennessee, the deformation of Silurian rocks preceding the deposition of the Devonian affected also the Kokomo or lower waterlime division.

In central Kentucky and in Tennessee the Devonian rests upon successively lower beds of the Silurian, on approaching the crest of the Cincinnati geanticline from the west. The unconformity at any single locality appears slight, but when localities distant from the crest of the geanticline are compared with those much nearer, it is observed that, notwithstanding the moderate inclination of the Silurian rocks, the Devonian at the more western exposures rests upon the Louisville bed, but that farther east it rests in succession upon the Waldron, Laurel, Osgood, Clinton, Richmond, and finally upon Lorraine beds. Similar conditions are noticed on the eastern side of the Cincinnati geanticline, in central and southern Kentucky.

It is likely that similar conditions obtained in southern and central Indiana. The Devonian formerly may have extended a considerable distance east of its present line of outcrops, and it is probable that it rested eastward upon successively lower beds of the Silurian. The thinning of the Louisville bed from Louisville toward Decatur County, and from Waldron toward St. Paul and Greensburg, is favorable to this suggestion. A study of the Silurian outcrops nearest to contact with the Devonian strata in Howard, Hamilton, and Madison counties may in the future shed much light upon this subject. The Kokomo limestone includes the highest Silurian strata so far identified in Indiana. In Hamilton County, the uppermost Niagaran strata contain the

*Conchidium* fauna belonging to the upper part of the Louisville section. At Pendleton, in Madison County, *Sphaerexochus romingeri* usually indicates the Louisville horizon, but it does not appear to be confined to any particular horizon. Future studies may suggest that the Madison County exposures occupy a lower horizon than those farther west.

The conditions in northern Indiana and in the adjacent parts of Illinois require much further investigation. At Elmshurst, west of Chicago, Silurian strata remained long enough above water level during early Devonian times to permit the widening of the cracks formed during their elevation. Some of these cracks were filled during the latter part of the Devonian by clayey material containing fish teeth and a few brachiopods.

## THE DEVONIAN PERIOD.

| Subdivisions in Indiana. | Corresponding subdivisions in New York. | Synonyms. |
|---|---|---|
| New Albany Black Shale. | Genessee, Marcellus. | |
| Sellersburg Limestone. | Hamilton. | Crinoidal limestone. |
| Silver Creek hydraulic limestone. | | North Vernon bluestone. |
| Jeffersonville limestone. | Corniferous. (Onondaga.) | |
| Geneva limestone. | | |
| Shelby beds. | | |
| Hartsville beds. | | |
| Pendleton sandstone. | Schoharie. (?) | |

Counties in which the Devonian strata outcrop in Indiana: Clark, Scott, Jefferson, Jennings, Jackson, Bartholomew, Decatur, Rush, Shelby, Johnson, Marion, Hancock, Hamilton, Boone, Clinton, Tipton, Madison, Howard, Carroll, Cass, Tippecanoe, White and Jasper.

A considerable portion of the north half of the outcrop of Devonian strata in Indiana is covered with glacial drift, in places several hundred feet deep. Hence the tracing of the partings and the correlation of the strata have been attended with great difficulty and consequently lack the degree of accuracy found in the groups which have continuous outcrops for study and com-

parison. Dr. Kindle* divides the exposed portions of the Devonian outcrop into three areas, designated the Wabash, Pendleton and Southern Indiana areas. These areas are separated by a wide expanse of drift-covered region in which no bed-rock outcrops have been found.

The southern Indiana area extends from near Indianapolis, southward across the Ohio River and outcrops in many places through Shelby, Bartholomew, Jennings, Jackson, Jefferson, Scott and Clark counties. The best exposures are in the southern portion, where the glacial drift is thin or absent and where the area is more deeply dissected by the streams flowing into the Ohio River. As one goes northward from the Ohio River the valleys become shallower and the glacial drift deposit heavier, and hence the underlying rocks show in fewer exposures. North from Shelby County the only exposures of the Devonian rocks through the drift are, the small area in the vicinity of Pendleton and several small areas in the vicinity of the Wabash River.

Pendleton is 28 miles northeast of Indianapolis, and 42 miles north of the northernmost outcrop of the Devonian rocks in the southern Indiana area. North and east of Pendleton the Niagara limestone outcrops. South there is no outcrop for more than 40 miles. West of Pendleton, in Hamilton County, there is an outcrop of limestone in several places; a limestone which was classed with the Devonian by Dr. R. T. Brown, but which Dr. Kindle places in the Niagara. The only Devonian rocks which Kindle finds in this area is a heavy-bedded, soft, white sandstone, which was named the Pendleton sandstone by E. T. Cox in 1876, and which Hall correlated with the Schoharie of New York. The correlation of the Pendleton sandstone with the Jeffersonville-Sellersburg beds in southern Indiana and with the Schoharie in New York is on a purely paleontologic basis. Well sections at Alert, Decatur County, show several feet of sandstone which is thought to be the equivalent of the Pendleton.

Kindle reports a local development of conglomerate in the top of the Pendleton sandstone, a conglomerate which consists of

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*Devonian Fossils and Stratigraphy, in 25th Ann. Rep., 1900, and Bull. Am. Pal., No. 12 1899, pp. 1-111. The following paragraphs on the Devonian are based largely on Kindle's papers and Siebenthal's paper on the Silver Creek hydraulic limestone in the 25th Ann. Rep., 1900, and Newsom's paper in the 26th Ann. Rep. Kindle's papers are devoted largely to the paleontology of the Devonian.

well-rounded chert pebbles, frequently 3 or 4 inches in diameter, in a matrix of coarse sand.

In the Wabash Valley between Peru and Delphi, and in the Tippecanoe Valley near Monticello, are a number of exposures of a fissile black shale which is correlated with the New Albany black shale of southern Indiana. The two divisions of the underlying limestone have been correlated with the Sellersburg and Jeffersonville limestones of the southern area. The distribution of these is shown on the map.

In southern Indiana the *New Albany black shale* is exposed over considerable areas. It is a black to blue-gray fissile shale containing much iron sulphide and a great deal of bituminous matter. The bituminous matter is so plentiful in places that it will burn freely and the volatile gases have been distilled from it. The shale is 104 feet thick at New Albany, and elsewhere it has been reported as much as 140 feet in thickness. The outcrop covers an area from 8 to 15 miles wide, as shown on the map.

The *Sellersburg limestone* of Kindle includes both the crinoidal and the hydraulic limestones, but Siebenthal limits the term Sellersburg limestone to the upper or crinoidal division and the lower hydraulic limestone he calls the Silver Creek hydraulic limestone. The Sellersburg limestone is a white to gray crystalline limestone that lies between the overlying black shale and the underlying hydraulic limestone. Frequently the basal portions are sandy and sometimes there is a layer of pebbly sandstone separating it from the underlying hydraulic limestone. The shining black pebbles are said to be rich in phosphates.

The *Silver Creek hydraulic limestone* lies between the overlying Sellersburg limestone and the underlying Jeffersonville limestone. It is a fine-grained, massively-bedded, argillaceous, magnesian limestone, light to dark drab in color, becoming buff on exposure. It is 15 to 16 feet thick at Silver Creek, 8 to 10 feet at Charlestown and 5 to 6 feet in the vicinity of Lexington.

The *Jeffersonville limestone* is a white to bluish gray crystalline, fossiliferous, flaggy limestone, lying between the Silver Creek hydraulic limestone and the underlying Niagara limestone. It has been correlated with the Corniferous of New York. It is exposed at the Falls of the Ohio River, and from it are obtained

many fine coral fossils. In this part of the area there was a great coral reef, not greatly unlike many forming at the present time, except the corals are a different class from the living ones.

Economic Geology.—The New Albany shale contains a great deal of bitumen and may sometime be used as a source of supply of gases and oils which could be distilled from it. It would not be profitable to do so at present, but it is a possible source of supply in the future when gas and oil are scarcer than at present.

The Sellersburg limestone is used locally for building stone, for lime, and for road metal. The Silver Creek limestone is used extensively and mainly for the manufacture of hydraulic cement. It makes an excellent cement and is widely used for that purpose.

The Pendleton sandstone has been used as a glass sand and also as a building stone. Prof. Cox (Ann. Rep. 1878, p. 61), says it has a good reputation as a building stone, both for beauty and durability.

## LOWER CARBONIFEROUS OR MISSISSIPPIAN PERIOD.

Subdivisions.

| *In Indiana.* | *In Mississippi Valley.* | *In Pennsylvania.* |
|---|---|---|
| Huron limestone and sandstone. | Chester, Archimedes, Kaskaskia, Pentremital. | Mauch Chunk red shale. |
| Mitchell limestone. | St. Louis. | |
| Bedford oölitic limestone. | Warsaw. | |
| Harrodsburg limestone. | Burlington. | |
| Knobstone shale. | Keokuk. | Pocono sandstone. |
| Goniatite limestone. | Chouteau. | |

That long and interesting time between the close of the Devonian and the beginning of the Coal Measures has been designated the Lower Carboniferous, the Subcarboniferous, and more recently the Mississippian period. The strata formed during this period in Indiana are prevailingly calcareous. The limestones contain much clay, sand and chert in places, but the greater part of the strata aggregating more than 1,000 feet in thickness are limestones of different textures and different degrees of purity. Attempts have been made at different times to correlate these differ-

ent subdivisions with strata elsewhere, but there is more or less question about the accuracy of any such correlations with the present data. It seems better at present to adopt the local terms and await more thorough study before correlating them with widely different strata.

The subdivisions that have been made are based largely on lithologic characters and for the most part there will be no confusion in identification. Later, when the faunas of the different groups have been thoroughly studied, correlations may be made with distant localities.

There appears to be no unconformity between the Lower Carboniferous strata and the underlying Devonian, and for that reason there has been some difference of opinion as to the proper place to draw the parting between them. Between the Lower Carboniferous and the Coal Measures there is a decided unconformity, marked by erosion. During the latter part of the Lower Carboniferous there was an uplift of the land area beginning at the north and progressing southward. During this elevation there was considerable disintegration and many channels were eroded on the land area. After the depression of the land, the Coal Measure strata were deposited uncomformably on this eroded surface.

The Indiana area was only a small part of the great interior sea that extended over the great part of the Mississippi Valley area in which the calcareous layers were accumulated. In Illinois, Iowa, Mississippi, Arkansas, Kentucky and Tennessee similar great thicknesses of limestone occur. On the eastern side of the Cincinnati Island the limestones contain more shale and sand, and in following them east one finds the sand and shale increasing until in eastern Pennsylvania, along the border of the interior sea, the limestones have disappeared entirely and the sediments of Lower Carboniferous age consist of a heavy bed of gray sandstone (the Pocono), overlain by a thick bed of red shale—the Mauch Chunk red shale. Thus, while the sands and mud were accumulating along the eastern shore, the limestones were being formed out in the clearer waters of this interior sea by the remains of the lime-secreting organisms.

### The Rockford Goniatite Limestone.

(Synonyms: Marcellus, Hall; Chemung, Hall; Chouteau, Worthen; Lithographic, Kindle.)

Counties in which the Rockford Goniatite Limestone outcrops: Clark, Scott, Jackson, and Bartholomew (?).

The Rockford Goniatite limestone is considered by some to be the first stratum formed in the Lower Carboniferous in Indiana, but some geologists think it ought to be classed with the Devonian. James Hall correlated it first (1861) with the Marcellus and later (1862) with the Chemung. Other correlations have been made with the Chouteau and with the Lithographic limestone of Missouri.

The different fossil forms that have been found in this limestone are listed in the Twenty-sixth Annual Report of this Department, pp. 258-260.

The Goniatite limestone is only a few feet in thickness, frequently not more than 2 feet thick, but it occurs widespread over southern Indiana. It is a close-grained fossiliferous limestone, having a conchoidal fracture and a greenish color when fresh, turning brown on exposure.

### The Knobstone.

Counties in which the Knobstone strata outcrop: Harrison, Floyd, Clark, Washington, Scott, Jackson, Lawrence, Monroe, Brown, Bartholomew, Johnson, Morgan, Owen, Putnam, Hendricks, Marion, Boone, Montgomery, Clinton, Tippecanoe, Fountain, Warren, White, Benton and Jasper.

Name.—The Knobstone group was so named as early as 1859 by D. D. Owen because of the peculiar conical hills or *knobs* which occur over its weathered outcrop.* The name has been accepted and used by geologists since that time, although it is unfortunate that a definite geographical term was not used. The few lithologic terms that have been used for designating a certain epoch or series in geology are gradually being replaced by geographic terms and Knobstone will probably be added to the list in the near future.

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*For particulars and detailed discussion of the group see 26th Annual Report, 1901, p. 260, by J. F. Newsom; and Report of a Geological Reconnaissance of the State of Indiana, made in 1837, by D. D. Owen, p. 21. Indianapolis, 1859.

Other local terms that have been applied to portions of this group are *New Providence shale* and *Riverside sandstone.* The first name was used in 1873 in the Fifth Annual Report, p. 61, by Borden, for the soft greenish or bluish shales in the vicinity of New Albany and New Providence. The sandstone quarried at Riverside above Attica on the Wabash River was named Riverside sandstone by the writer* in 1896, because at that time there was not sufficient data available to definitely correlate it with the Knobstone of southern and central Indiana. Since the correlation has been made the name Riverside should be dropped as a geological term. It may still be used as a commercial term.

KIND OF ROCK.—The rocks of the Knobstone consist of blue gray shales, shaly sandstone, sandstone and rarely a little limestone. In central and southern Indiana where they are best developed the group is divided by Newsom into (1) the New Providence shale at the base, overlain by (2) the Upper Knobstone shale and (3) the Knobstone sandstone. There is considerable variation locally in the relative percentage of sandstone and shale, with the shales prevailing at the base of the group and sandstone at the top. The color is prevailingly bluish gray to greenish gray, changing to buff on the much weathered exposure.

Toward the northern limit of the Knobstone area there is considerable limestone that is thought by some to belong to the Knobstone group, but which the writer thinks is properly correlated with the overlying Harrodsburg limestone, and he so designates it on the map.

CHEMICAL COMPOSITION.—The Knobstone varies considerably in composition in different parts of the area. The most marked variation is in the sand and clay constituents, in some places grading into sandstone and elsewhere into sandy shale. The sand becomes very fine in some places but generally forms an appreciable part of the rock. The following analyses indicate the general chemical character. The first one is a sandstone, the next two are shales.

PARTIAL ANALYSIS OF KNOBSTONE FROM RIVERSIDE, IND.

Insoluble residue, 93.16 per cent. Alumina, 1.6 per cent. Iron oxide, 2.69 per cent. Lime, 0.13 per cent.

*20th Ann. Rep., p. 317, 1896.

ANALYSES OF KNOBSTONE SHALES FROM JACKSON COUNTY, IND.

| | | | | |
|---|---|---|---|---|
| Silicia ($SiO_2$) | 59.64 | | 64.59 | |
| Titanium oxide ($TiO_2$) | 1.05 | | .30 | |
| Alumina ($Al_2O_3$) | 19.14 | | 16.37 | |
| Combined water ($H_2O$) | 4.36 | | 3.71 | |
| Clay base and sand | | 84.19 | | 84.97 |
| Ferric oxide ($Fe_2O_3$) | 3.39 | | 5.37 | |
| Ferrous Oxide (FeO) | 4.20 | | 1.59 | |
| Lime (CaO) | .26 | | .16 | |
| Magnesia (MgO) | 2.31 | | 1.56 | |
| Potash ($K_2O$) | 3.53 | | 4.24 | |
| Soda ($Na_2O$) | .80 | | .97 | |
| Fluxes | | 14.49 | | 13.89 |
| Carbon dioxide ($CO_2$) | | .35 | | .43 |
| Total | | 99.03 | | 99.29 |

THICKNESS.—The Knobstone group reaches a maximum thickness of 650 feet at Bloomington, near the center of the State. At St. Joseph, in Floyd County, it is 550 feet; at Rockville, Parke County, it is 530 feet. Near New Albany in the southern part of the State it is 471 feet. It apparently thins out and probably disappears in the northern portion of the State but the northern limit is concealed by a heavy mantle of drift.

DISTRIBUTION.—As shown on the map, the Knobstone group outcrops over a belt of quite variable width, extending in a west of north direction from the Ohio River to north of the Wabash River, and possibly further to the northwest, as the area there is so covered with drift as to conceal the underlying rock. The extreme northwest limits as shown on the map are only approximate, based on the very limited data at hand. The widest portion of the area is in the south-central portion of the outcrop in Jackson, Monroe, Brown and Bartholomew counties, where it is from 25 to 38 miles wide. It narrows very perceptibly to the south to scarcely six miles in width at New Albany.

TOPOGRAPHY.—"The generally narrow, V-shaped valleys cutting the country in all directions, apparently without any systematic arrangement, form the most noticeable and important topographic characteristic of the Knobstone area. In the central area, particularly, the valleys are well developed. Here they

have the tangled, dendritic arrangement common to flat, plateau countries, where folds and faults are absent." *(Newsom.)*

A noticeable feature throughout the whole Knobstone area, where the valleys are well developed, is that the south-sloping hillsides have much steeper slopes than the north-sloping areas. This difference is thought to be caused by the different temperature changes. Thus the hillside sloping south faces the winter's sun, which thaws it during the day, and it freezes again at night. It is this constant freezing and thawing which weathers the shale much more rapidly than on the north-facing hillside, which lies in the shadow, and is often covered with snow for many days and weeks when the sun and frost are disintegrating the south-facing hill.

There is some difference also between the east and west sides of the north-south valleys, but it is not so marked as in the preceding. The slope on the east side receives the afternoon sun, which is warmer than the morning sun, and hence the tendency is to weather more rapidly, but the difference is not so marked as in the east-west valleys.

The Harrodsburg limestone and Bedford oölitic limestone overlying these shales are so much more durable, that along the western border of the Knobstone area they form a protecting cap over the Knobstone, which weathers away more rapidly, until the cap rock breaks down from its own weight. Where there is no active stream these boulders accumulate in talus slopes, often concealing the Knobstone outcrop. Where there is an active stream to remove the talus, the Knobstone forms scaling-vertical walls underneath the harder limestone which frequently overhangs. In the northern part of the area, where the overlying limestones do not occur and the Knobstone is overlain by the Mansfield sandstone, which is still more durable, the top-heavy cliffs are even more conspicuous than in the limestone area.

A characteristic feature of the weathering of the Knobstone on all the cliff exposures is the exfoliation or the flaking off of thin slabs parallel with the surface and independent of the bedding. These foliation planes are sometimes so pronounced as to be mistaken for the bedding planes.

There is not the alternation of hard and soft layers so common in many limestone beds, and hence the absence of rock terraces

caused by such alternation. While there is a uniformity in the relative hardness and weathering qualities of the different layers, there are irregular patches and pockets of softer and harder materials, so that the weathered surface is sometimes pitted by the weathering out of the softer spots and sometimes studded with siliceous concretionary masses.

SPRINGS.—Like most shale formations, the Knobstone shales absorb moisture freely but do not transmit it freely, so that it is not a water-producing stratum, and is relatively impervious when compared with the overlying limestones in the central and southern areas or the sandstone of the northern portion. Hence, where it forms the base of the hills which are capped with limestones or sandstones, the top of the shales is a marked horizon for springs, as the waters which find ready passage down through the pores of the sandstone or the caves, joints and fissures of the limestone are led to the surface on the hillsides along the top of the less pervious Knobstone shales.

ECONOMIC.—In a few places the more sandy portions of the Knobstone have been quarried and used as a building stone. Such quarries occur at Riverside on the south bluff of the Wabash River, opposite Independence, and on the north bluff opposite Attica, and at several places along the C. I. & W. Railway, near Raccoon Station. It does not appear to be used so much toward the southern end of the area, possibly because of its proximity to the oölitic limestones which form a better building stone.

It is not a very durable building stone, especially in the presence of moisture, and hence is not adapted to foundations and bridges, where it has been used too frequently. In the walls of buildings above the foundations or as trimmings for brick or stone buildings it is quite serviceable if quarried and selected with some care. It has a fine grain and generally uniform color, either yellowish buff, as generally found in the top layers, or a blue gray in the deeper unoxidized layers. The fineness and evenness of grain, the uniformity in color, the ease with which the stone can be cut and carved are all strong points in its favor as a building stone. If the stone is selected with care and quarried and dressed with proper precautions and laid in proper position in the wall, it can be used safely and with good architectural effects.

The Knobstone shale at Blue Lick, Jackson County, is now being used in the manufacture of *Portland cement,* and there is no apparent reason why larger quantities of it should not be used for this purpose. Points that would apparently indicate an increased use of the Knobstone shale in cement making are (1) its proximity to the excellent limestone beds overlying it and its short distance from the coal fields; (2) uniformity in composition, and (3) ease of quarrying and preparation. In many places the shale and the limestone may be obtained from the same hillside, but generally it may be found more desirable to quarry them at different points because the limestone immediately overlying the Knobstone is generally not a good limestone for cement purposes. The shales may be a little harder to pulverize and mix with the lime ingredients than the softer clays that are sometimes used, but this may be more than counterbalanced by greater uniformity of composition and great thickness of the beds. Care, of course, is necessary in selecting a suitable locality where the shale is not too sandy and has the proper composition.

In many places the Knobstone shale will furnish excellent material for brick making, for either vitrified brick or common brick. It has been used for this purpose at New Albany and probably will be used for similar purposes in many other localities. It is true that Indiana has an abundant supply of brick-making shales in the Coal Measures close to the fuel supply, but for the bricks used along the Knobstone belt it would be cheaper to ship in the coal than the bricks, to say nothing of the increased commercial advantage in having the factory at home and the increased use of the bricks to the improvement of the streets and the buildings.

### The Harrodsburg Limestone.

(Synonyms: Burlington, Keokuk, Encrinital.)

Counties in which the Harrodsburg limestone outcrops: Floyd, Clark, Washington, Jackson, Lawrence, Monroe, Owen, Putnam, Parke, Montgomery and Fountain.

Overlying the Knobstone group and underlying the oölitic limestone is a series of rocks that has been variously designated in the older geological reports of Indiana. It was early known

as the Encrinital limestone, from the abundant crinoidal remains. It has also been correlated with both the Burlington and Keokuk groups of Iowa. Owing to the uncertainty of the correlation, especially the delimitations of the group, the present State Geologist and his assistants thought it best to use a local name and clearly state its delimitations, and await more thorough paleontological knowledge before correlating with formations so widely separated as are these rocks from Burlington and Keokuk. The name Harrodsburg limestone, from a village of that name in the southern part of Monroe County, was first used in 1896 by Hopkins and Siebenthal in the geology of the oölitic limestone district of Bedford and Monroe County, and this name has been used in all of the reports since 1896. It includes all the beds between the Knobstone shales below and the Bedford oölitic limestone above, and is generally quite sharply separated lithologically from the oölitic limestone above, but grades into the Knobstone shales below in many places.

The Harrodsburg group consists chiefly of limestones which frequently contain a great many crinoidal remains and many well preserved crinoid heads at Crawfordsville and vicinity, a locality which is known in all the large museums of the world for its fine crinoid specimens. Intermingled with the limestone layers are thin layers of shale and small quantities of chert. In the limestone, and less commonly in the shaly layers, quartz geodes occur often in great numbers. These appear to be more abundant in the lower than in the upper layers, and occasionally occur in the underlying Knobstone layers.

There are many stylolite seams at various levels, and nearly always a prominent seam of this kind occurs at the top of the group separating it from the oölitic limestone.

The limestone is in places coarsely crystalline, especially the crinoidal layers. The crinoid stems are always coarsely crystalline calcite, and the ground mass in which they are imbedded is crystalline in part, but consists largely of mud deposits. In the Heltonville locality the upper layers consist almost entirely of fragmental bryozoa, the delicate, lace-like appearance of which is very pretty on a broken or polished surface. It has been used in a limited way for an ornamental stone.

EXTENT.—The Harrodsburg limestone outcrops along a belt extending from the Wabash River in Warren and Tippecanoe counties in an east of south direction to the Ohio River and beyond into Kentucky. The outcrop varies in width from a few feet to several miles. It extends further north than the succeeding stratum, the Bedford oölite, but not as far as the underlying Knobstone. There appears to have been an elevation of the land and consequent recession of the sea during this part of the Mississippian or Lower Carboniferous period. The area covered by the outcrop of the Harrodsburg limestone is shown in detail on the State map.

In the central area the Harrodsburg limestone and shales vary from 60 to 90 feet in thickness. It thins out somewhat to the north and near the northern limits it appears only in isolated patches. A detailed section of the different layers near Harrodsburg indicates the general character of the stone for the central area.

SECTION OF THE NORTH BLUFF OF JUDAH'S CREEK, ONE MILE SOUTH OF HARRODSBURG.

| | *Feet.* | *Inches.* |
|---|---|---|
| Massive fossiliferous limestone | 6 | 0 |
| Gray heavy-bedded limestone | 16 | 0 |
| Blue argillaceous shale | 2 | 0 |
| Limestone | 0 | 4 |
| Chert | 0 | 3 |
| Heavy-bedded blue to gray crystalline limestone | 6 | 0 |
| Yellow calcareous shale with geodes | 1 | 3 |
| Fine, heavy-bedded blue crystalline limestone | 11 | 0 |
| Flaggy limestone | 1 | 0 |
| Gray argillaceous limestone | 0 | 10 |
| Calcareo-argillaceous shale with bands of limestone and some geodes | 18 | 0 |
| Heavy limestone, weathering shaly | 3 | 0 |
| Calcareous shale in bed of creek | ? | ? |

The thickness over the southern portion of the area is stated to be 35 to 100 feet, averaging about 65 feet. The general character of the rock in the southern area resembles closely that in the central area, consisting of interstratified limestone and shale with many geodes and chert concretions.*

*See 27th Ann. Rep., Lower Carboniferous of southern Indiana, by G. H. Ashley.

The geodes of the Harrodsburg limestone vary in size from a fraction of an inch to several feet in diameter. They consist of an outer crust of crystalline quartz or quartz and chalcedony, which is lined or entirely filled with crystals. These crystals are most commonly quartz or calcite, or the two together; frequently quartz lining the shell and the central space filled with calcite. Several other minerals occur in smaller quantities, the most common ones being the metallic sulphides, pyrites and marcasite, the iron sulphides; galena, the lead sulphide; sphalerite, the zinc sulphide; and millerite, the nickel sulphide. In certain localities the geodes are very abundant; as many as 100 may be seen at one time on some of the cliffs bordering the creeks, and hundreds of others occur among the boulders and gravels of the creek bed. So abundant are they in places that the gravel bars on the creeks are composed almost entirely of geodes and geode fragments.

Economic.—The Harrodsburg limestone has a limited local use for building stone and for road metal. Its use is more limited than it would be otherwise by its proximity to the Bedford oölite, a much better building stone which is used in preference, and the Mitchell limestone proves to be a much better road metal and is used, or should be used, in preference where it can be obtained at reasonable cost.

### Bedford Oölitic Limestone.

(Synonyms: Oölitic stone; Bedford rock; Bedford stone; Indiana oölitic stone; Spergen Hill limestone; White River stone; St. Louis limestone; Warsaw limestone.)

Counties in which the oölitic limestone outcrops: Harrison, Floyd, Washington, Lawrence, Monroe, Owen, Putnam, Montgomery.

References—

The Bedford Oölitic Limestone of Indiana, by T. C. Hopkins and C. E. Siebenthal—Twenty-first Ann. Rept. Dept. Geol. and Nat. Resources. See p. 411 for other references.

The Lower Carboniferous Area in Southern Indiana, by Geo. H. Ashley, in Twenty-seventh Ann. Rept., 1902.

The Mineral Industry, New York, Vol. IV, 1894, p. 505.

Nearly all the Annual Reports of the Department of Geology and Natural Resources of Indiana have short articles on the Bedford oölitic limestone.

The next stratum overlying the Harrodsburg limestone is a massive whitish oölitic limestone that has been described in the recent geological survey reports as the Bedford oölitic limestone. It has been referred to in earlier reports as Indiana oölitic stone, Spergen Hill limestone, White River stone, St. Louis limestone, Warsaw limestone, etc. Of all the many names which have been given to it, the Bedford oölitic limestone is thought by the present survey to be the best because it is a limestone, it is oölitic, it is typically developed in the vicinity of the city of Bedford and is known commercially throughout the State and the Union as the Bedford oölitic limestone.

The rock is a granular limestone or calcareous sandrock in which both the grains and the cement are carbonate of lime. It differs from sandstones, which it resembles in appearance, by having rounded grains instead of angular, grains composed of soft shells or fragments of shells instead of quartz, and hence is more easily cut and carved. It differs from nearly all other varieties of limestone in being more granular and more easily cut and carved into any desired shape. There is considerable variation in the size and regularity of the grains at different places. A fine grain of uniform size is the kind most sought after for building purposes. The coarse crystalline texture is not adapted to carved work or fine tool dressing. The grains are shells and shell fragments, consisting chiefly of minute forms of foraminifera, small bryozoa, brachiopods and gasteropods.

The fossils are imbedded in a cement of calcite and the hardness and compactness of the stone is governed by the relative amount and purity of this cementing substance. The firm crystalline cement gives the stone strength and the soft, partly hollow shells prevent it from being too hard to work easily under the tools of the stonecutter.

The stone occurs in a massive bed varying from a few feet up to 100 feet in thickness, and for the most part nearly free from bedding planes. The lamination appears in many places on a weathered surface and in a few places even cross-bedding is brought out by the weathering. In a number of places the bedding planes are marked by the black jagged points of the stylolites, the so-called "crow foot" or "toe nail" of the quarrymen. These black streaks are all too frequent in many localities

and cause large quantities of the stone to be thrown out on the waste, as they injure the strength of the stone as well as disfigure it.

The prevailing colors of the Bedford stone are blue and buff. The upper portion, extending down to a variable depth, is buff, and the deeper portions are blue. The parting between the two colors is commonly an irregular one and frequently causes the waste of considerable stone. In many places the stone has a light gray nearly white color on the weathered surface.

The blue appears to be the original color and the color that prevails in the deeper parts of the quarry. The buff is the secondary product, derived from the blue by the surface waters carrying down more or less oxygen which changes the lower oxides of iron to the higher, with corresponding change in color, or oxidizes the diffused carbonaceous matter. The depth to which the oxidation extends is sometimes only a few inches and in some places it extends to the bottom of the oölitic stone.

The Bedford stone has an average specific gravity of 2.47. Chemically it is a nearly pure carbonate of lime, varying from 95 to 98.25 per cent. of that substance. Probably no other limestone shows such a uniformly high percentage of lime.*

The oölitic limestone has no very marked effect on the general topography, as it lies in the midst of the limestones of almost equal durability. Where the outcrop has any considerable width, the surface is gently undulating. Quite frequently the outcrop is in the hillside, where it forms most commonly a steep cliff, and if along the stream channel, frequently an overhanging ledge, owing to the more rapid weathering at the base of the cliff, near the water. It is less subject to sink holes, depressions and caves than many of the other limestones.

Economic Features.—The Bedford oölitic limestone ranks among the finest building stones in the United States, and from a commercial standpoint stands first among the rocks quarried in Indiana in both the quantity and quality of the stone quarried. This stone has been shipped to nearly every state and city in the United States and some foreign countries for use in public and private buildings; especially is it used extensively in the two largest

*For list of chemical analyses of the oölitic limestone see 21st Ann. Rept., 1896, p. 320.

cities, New York and Chicago, where it continues to grow in favor. It is also used extensively for monumental purposes.

The properties which make this stone valuable for building purposes are: (1) Its easy *workability*. It occurs in large masses, from which blocks of any required dimension may be obtained. It can be cut from the quarry with greater ease than almost any other rock, and after removal from the quarry it lends itself kindly to further cutting and carving. Probably no other building stone quarried in this country is better adapted to carved work than this. Its freestone nature, comparative softness, and freedom from lamination fit it for work of this character. Like nearly all building stones, it is softer and more easily cut and carved when first quarried, and becomes much harder and less tractable after seasoning.

(2) Uniformity of color and texture is another desirable quality in building stone in which the Bedford stone excels. Except along the generally somewhat irregular line of contact of the blue and the buff stone, the rock has either a uniform blue or uniform buff color, and rare indeed is the instance of patches, streaks or stains of other colors to mar the uniformity. The buff color is the one most in demand although a number of years ago the blue colored stone was most sought.

(3) Durability is one of the most important properties of a good building stone and one in which the Bedford stone excels. While its rather soft, granular structure might indicate otherwise, it has proven itself to be one of the most durable building stones on the market. Its ability to withstand disintegration is shown (a) by the bold cliffs and the smooth faces on many outcrops; (b) by the sharp corners, square blocks and even faces of the old quarries where the stone has been exposed for many years, and (c) by the good state of preservation of the stone in many old buildings where it has been exposed to the elements for many decades.*

(4) Transportation facilities. It will be noticed on the map that the entire area of the Bedford stone is fairly accessible to railways. The Monon Railway traverses the area lengthwise from Salem northward and several east and west lines cross the belt at different points.

*Specific instances and figures in corroboration of the above statements may be found in the Annual Report State Geologist, 1896.

DISTRIBUTION.—The areal distribution of the Bedford oölitic stone is shown on the accompanying State map,* where it will be seen to extend from Montgomery County south across the Ohio River, a distance of 142 miles in the State of Indiana. The rock loses its massive structure just north of Romona, on the White River, and in its northern extension becomes thin bedded or even shaly on some of its exposures. While it thus loses its massive structure and hence its value as a building stone, it retains its characteristic granular texture and fossils.

It outcrops on the hill a quarter of a mile north of Parkersburg in the southern border of Montgomery County, which is the most northern outcrop of it observed by the writer in the State.†

It is exposed at many points through Putnam County. It outcrops along the Monon Railway northeast of Greencastle in sections 22, 23, 34, and 35, T. 13 N. R. 4 W. It has been quarried for road metal in Greencastle in the quarry a few hundred yards northeast of the Monon depot, where a thickness of many feet is exposed on the quarry face. There is another outcrop in the gully crossing the Indianapolis & St. Louis Railway about a mile east of the depot. At many other points in the southern and southeastern parts of Putnam County the rock is exposed and at several places has been quarried for local use as road metal. There are a number of similar exposures in northeastern Owen and northwestern Morgan counties in T. 11, 12, and 13 N. and R. 2 and 3 W.

Outcrops of similar stone becoming a little more massive in structure occur over the area south of Quincy and between that point and Romona, where it first appears in a massive bed, and where the first large building stone quarry is met as one goes south.

Quarries of oölitic limestone have been operated at the following points going southward: Romona, Big Creek, Stinesville, Ellettsville, Bloomington (Hunter Valley), Sanders, Clear Creek, Peerless, Buff Ridge, Smithville, Harrodsburg, Spider Creek, Bed-

*More detailed and larger scale maps of the productive area between Salem and Quincy may be found in the 21st Ann. Rep. of this Survey for 1896, and larger scale maps of the area south from Salem may be found in the 27th Ann. Rep. accompanying the paper by Dr. Ashley.

†There is an oölitic limestone exposed near Darlington, ten miles northeast of Crawfordsville, but it is the concretionary oölite, quite different from the Bedford stone and which resembles the oölite found at several different places in the Huron group in Lawrence and Orange counties.

ford, Oölitic, Reed's Station, Heltonville, Fishing Creek, Rock Lick and Salem.

The quarries at Romona show a greater thickness of stone than at any of the other localities, but it is a little more crystalline and coarser grained than farther south, and is therefore better adapted to heavy masonry than to fine carved work. The Big Creek quarries have been abandoned for many years. At Stinesville and Ellettsville the quarries have been in operation for many years and are still productive, furnishing stone of fine quality. The Hunter Valley district near Bloomington is newer than the above, yet has had a number of large quarries and mills in operation for a number of years (since 1891). Between Bloomington and Bedford a good many quarries have been opened in the oölitic stone, some of which are still in operation and some have been abandoned.

Bedford is the center of the largest development along the oölitic belt. The Blue Hole quarry near the city, and the Dark Hollow, Reed's Station, and Oölitic Station quarries northwest of the city, are the more important quarries in the vicinity. All of these quarries are connected with Bedford by one or more lines of railway, and several large stone mills are located in the city.

The developments south of Bedford have not been so extensive as those at and north of that city. During the year 1901 a large quarry was opened in the Fishing Creek district, but has since been abandoned. South from Salem the stone has been quarried to some extent for local use but not for shipment. (See paper in the Twenty-seventh Annual Report by Dr. Ashley.)

## Mitchell Limestone.

(Synonyms: Cavernous limestone, Barren limestone; St. Louis limestone.)

Counties in which the Mitchell limestone outcrops: Harrison, Floyd, Crawford, Washington, Orange, Martin, Lawrence, Monroe, Greene, Owen, Morgan, Putnam, Parke and Montgomery.

Name.—Overlying the Bedford oölitic limestone is a heavy bed of compact limestone and chert, with small quantities of intercalary calcareous shales, which has been called the Mitchell lime-

stone by the Blatchley survey. It was first so called in the Twenty-first Annual Report in 1896. In the reports previous to that time it was called the St. Louis limestone, but there is good reason to think that it corresponds only in part with the St. Louis limestone of the Mississippi Valley, and since it forms a fairly well marked stratigraphical unit it was thought best to give it a local name that definitely fixes its position. It is named from Mitchell, a village in the southern part of Lawrence County.

The lower limit of the Mitchell group is the Bedford oölitic stone, the upper limit is the Huron sandstone, shale or limestone, or in the absence of the Huron, the Mansfield sandstone. In the middle portion of the area it ranges from 150 to 250 feet thick, thinning out toward the north and thickening to the south, as at Corydon, in the southern part of the State, it is 350 to 400 feet thick.

DESCRIPTION.—The Mitchell group in Lawrence County consists of limestones, shales and chert. The lower portion consists of yellow, drab or gray limestone; the upper portion consists of compact blue and gray limestone with some intercalary shales and considerable gray chert. Following is a detailed section of the Mitchell in one locality:

SECTION OF THE MITCHELL LIMESTONE IN T. 7 N., R. 2 W., SEC. 13.

| | *Feet.* |
|---|---|
| Drab lithographic limestone, *L.proliferum*, in top layer | 20 |
| Chert breccia, rotten lithographic groundmass | 8 |
| Bluish drab, fine-grained, fetid limestone | 10 |
| Lithographic limestone | 4 |
| Drab calcareous clay shale | 9 |
| Drab rotten, magnesian limestone with chert inclusions | 29 |
| Bluish, vermicular, shaly limestone | 2 |
| Drab calcareous shale | 4 |
| Rotten and shaly lithographic limestone | 5 |
| Lithographic limestone | 2 |
| Rotten lithographic limestone | 5 |
| Drab calcareous shale | 7 |
| Fine-grained, bluish-gray limestone with conchoidal fracture. | 5 |
| Calcareous clay shale | 2 |
| Gray limestone in eight-inch beds | 5 |
| Fossiliferous shaly limestone | 14 |
| Concealed | 6 |
| Fossiliferous coarse-grained limestone | 2 |
| Oölitic limestone | — |

The following section shows the character of the beds in the southern part of the area:

SECTION OF PART OF THE MITCHELL GROUP NEAR CORYDON HARRISON COUNTY.

| | *Feet.* | *Inches.* |
|---|---|---|
| Buff to drab and pink, shaly limestone | 8 | 0 |
| Outcrop of same rock, showing only clay to which the limestone has weathered, buff, yellow and red | 3 | 0 |
| Hard light drab limestone | 0 | 1-½ |
| Light brown to nearly black, fissile shale | 0 | 6-8 |
| Solid, dark blue limestone | 3 | 0 |
| Light brown shale and limestone | 1 | 0 |
| Light brown to blue shaly, hard limestone | 2 | 6 |
| Light brown fissile shale | 0 | 6 |
| Light drab limestone, with plates of chert | 4 | 6 |
| Soft, dark drab shale | 0 | 6 |
| Drab limestone | 5 | 0 |
| Drab limestone, softer than last, to railroad track (12-15 feet above creek) | 2 | 0 |

In a number of places a portion of the rock has the texture of a lithographic stone, but as yet no one has found it in sufficiently large blocks free from defects to have any commercial value for lithographic purposes. It contains minute veins and scattered crystals of calcite. The lithographic stone is practically free from fossils.

In a great many places throughout the area a good quality of flagstone and heavy building stone could be obtained from the bold outcropping ledges of the limestone. The chert occurs in varying quantities at different horizons, sometimes a few scattered nodules which may increase in size and number until they replace a greater part of the limestone. On the weathered exposures the lime carbonate is leached out and the chert fragments left in large numbers through the residual limestone clay. Over a large part of the area south of the glacial limit the surface is characterized by this deep red to reddish brown clay with its many angular chert fragments.

CAVES.—The greater part of the area of the Mitchell limestone is characterized by many caverns, large and small, which find expression on the surface in many sink-holes, all of which lead into caverns. The question arises, why should there be more caverns in this limestone than in any of the others? It is not easy to give

a decisive answer, yet the following suggestions may partially account for it: (1) The stone has a great many open joints, in and along which the meteoric waters are active. (2) The abundance of chert fragments on the weathered surface makes a porous soil mantle which absorbs a large per cent. of the rainfall and conveys it to the limestone. (3) The soil is quite fertile, hence there is a heavy growth of vegetation, the decaying portion of which furnishes the acids to the percolating waters, thus making them more active agents of dissolution. These caves are most abundant in the central and southern portion of the belt, but occur all over the area. Marengo and Wyandotte are two of the best known caves in Indiana, but there are scores of smaller and less noted ones throughout the area covered by the Mitchell limestone. The Mammoth cave and other large caves in Kentucky are in the southern extension of this same belt of limestone. The University cave at Greencastle is one of the most northern caves on the belt.*

TOPOGRAPHY.—The Mitchell limestone is characterized topographically by the numerous sink-holes over the area where it occurs, and by the scarcity of surface streams. Nearly all the drainage is subterranean, through the numerous caves. A few valleys have cut down through the limestone or down into it as far as the permanent water plane, and they receive the subterranean drainage in large springs that are the openings where the cave streams come to the surface. One of the most interesting of these underground streams is Lost River, in Orange County, which flows over the surface for a few miles near the head and then drops through one of the many sink-holes and flows as an underground stream for about eight miles, when it emerges as a large spring, the head of Lost River. During wet seasons all the water can not get into the sink-hole and the surplus flows over the surface through what, for the remainder of the year, is the "dry channel of Lost River." Part of this subterranean channel is said by Mr. Kindle to be in the overlying Huron limestone.

As may be seen on the map, the Mitchell limestone has a wider outcrop than any of the other groups in the Lower Carboniferous except the Knobstone. This greater width is due partly to its greater thickness and partly to the more level surface of the out-

*See paper on Indiana caves and their fauna, by W. S. Blatchley, 21st Ann. Rep., p. 121, which also contains bibliography of other papers.

crop. It forms a broad, rolling sink-hole area between the higher hilly region of the Huron and Mansfield groups on the west and the generally lower hills and valleys in the Bedford oölitic limestone on the east.

Economic Features.—The stone is quarried in large quantities and used for road metal, wagon roads or railways; for flagstone, for paving and curbing, for burning to quick-lime and for building stone. It is one of the best road metal stones in the State of Indiana. It wears and packs better than the more granular oölitic stone or the more crystalline Harrodsburg. It compares favorably with the Niagara limestone of Silurian age in this respect, and is generally superior because the Niagara in many places has thin layers of intercalary shale which, if not separated in the quarrying, will quickly form mud on the roads.

The Mitchell limestone has been used quite extensively, especially during the last few years, in macadamizing the roads in the area where it occurs. Many small quarries have been opened in which the stone has been quarried for local use. Some of the largest railway quarries where the stone is quarried primarily for railway ballast are those at Williams' Station on the Indiana Southern Railway; at Spencer, Indiana, on the Indianapolis & Vincennes Railway; at Greencastle, Indiana, on the Vandalia Railway; at Greencastle, on the Big Four Railway; at Okalla, Putnam County, and on the Vandalia Railway near Waveland. Each of these quarries is capable of turning out from 10 to 25 or 30 carloads of crushed limestone per day.

The largest and best flagstone quarries in the Mitchell limestone are those at Putnamville, Putnam County, which have been in operation for many years, and have furnished large quantities of flagstone to neighboring towns. The flagstone is a superior quality, being very strong and durable. It is not used as extensively now as formerly on account of the expense of producing it as there is a heavy overburden to be removed before it can be obtained. The Putnamville stone has also been used extensively for building stone.

Much of the Mitchell limestone is a comparatively pure carbonate of lime and, when burned, makes a strong, fat quicklime. It has been burned for local use at many points throughout the area in small intermittent kilns. Lime has been burned in large

quantities at the following points: North of Mitchell on the Monon Railway, near Williams Station, Spencer, Cataract, Cloverdale, Putnamville, Okalla and Waveland . While lime has been burned at the above points, at only a few of them is it being burned at present.

As mentioned above, at many places the stone has a fine lithographic texture and considerable money and energy have been spent in trying to open up a good workable deposit of lithographic stone, but so far it has been in vain, the rock all having minute scattered crystals and veins of calcite. There remains a possibility of yet discovering a limited area of this rock suitable for lithographic stone, although experience in this line has not been encouraging.

Where it occurs free from the nodular chert, the Mitchell limestone in most places forms a very good building stone. It lacks many of the valuable qualities of the oölitic stone, and because of its proximity to that valuable stone, it probably will never be used extensively for building purposes. It lacks the massiveness of the oölitic stone and can not be obtained in such large blocks. It lacks the freestone character of the oölitic stone, hence it is not so easily carved and dressed. It occurs in thin beds and with numerous joint seams which facilitates its removal in rough blocks, thus adapting it to local use for foundations, bridge abutments, well-curbs, steps and similar uses. It is occasionally used for superstructures. The quarry at Putnamville is the only one that ships dimension stone to any distance.

DISTRIBUTION.—The most northern limit of the Mitchell limestone, so far as definitely recognized by the writer, is in the southwest corner of Montgomery County. However, the heavy bed of chert on Flint Creek, in the Wabash Valley above Attica, probably belongs to the Mitchell horizon. There is no limestone associated with this deposit of flint and it contains no fossils so far as observed. It resembles the chert which occurs abundantly in the Mitchell further south, and does not occur in the strata immediately below, or above, so it seems quite probable that the Mitchell group is represented at least as far north as the Wabash River in the eastern border of Fountain County. It occurs in heavy beds of limestone, locally including much chert, in Putnam, Owen, Monroe, Greene, Lawrence and Orange counties and on south to the Ohio River and beyond. In Putnam County it outcrops in large

quantities through the central and western part of the county. The large quarries in Greencastle are all in this rock, except the one a short distance north of the Monon depot, which is in the oölitic. The quarries at Limedale, at Okalla, Putnamville and Cloverdale are in the Mitchell limestone. It also outcrops in large quantities along Little Walnut Creek, most prominently at Clinton Falls.

In Owen County the Mitchell limestone outcrops abundantly in a broad belt stretching through the county from north to south. The famous falls at Cataract are on this rock, which is pretty well exposed in the cliffs at and near the falls. The large quarry just west of Spencer is in this limestone. It turns out 20 to 25 carloads per day and employs about 70 men. The quarry face shows a thickness of 75 feet of compact blue limestone with a little nodular chert near the top of the quarry. Some of the layers have the fine, lithographic grain, but, as in other localities, there is too much crystalline calcite.

South from Spencer through western Owen and Monroe counties, the Mitchell limestone outcrops in large quantities, showing in the lower part of the steep hillsides, which are capped by the Huron sandstone and limestone and which stretch out eastward over a low area covered with residual clay containing great quantities of chert fragments. It is likewise an area of many sink-holes and caverns.

Going southward through Lawrence County the Mitchell limestone apparently increases in thickness and the width of the outcrop. Many cliffs and rocky hillsides of this limestone appear along Richland, Popcorn, Spring and Indian creeks. Small quarries are numerous from which stone is taken for local use, as road metal, well curbing, for foundations, bridges, etc. Near Williams' Station, on the Southern Indiana Railroad in the western part of the county, in the White River Valley, is the largest Mitchell limestone quarry in the county. The face of the quarry shows a thickness of 100 feet of limestone with almost no overburden and the entire thickness is quarried and put through the crusher. The rock is mostly gray limestone, shading into blue in places and showing thin but irregular seams of blue clay between the layers in places. The upper portion of the quarry exposure shows

a rather thick-bedded limestone, the bottom portion is thin-bedded. Chert nodules occur, scattered through the basal portion.

South of White River the Mitchell limestone outcrops over a broad area from Huron Station on the west to several miles east of the village of Mitchell. In the western part of the area between Georgia and Huron stations the Mitchell limestone lies at the base of the hills that are capped with the Huron limestone and sandstone and in the extreme western part of this area the Mansfield sandstone occurs on the hilltops. In the eastern portion of the area, from near Georgia to beyond Fishing Creek, the Mitchell limestone forms the top and upper portion of the hills overlying the Bedford limestone which outcrops at the base of the hills. Near the eastern border of the area the caves and sinkholes are more prominent. In the upland area surrounding the village of Mitchell there are large quantities of chert fragments scattered through the reddish brown clay soil. (For details concerning the distribution of the Mitchell limestone in the southern part of the State, see The Lower Carboniferous in Southern Indiana, by Geo. H. Ashley in the Twenty-seventh Annual Report, Geological Survey of Indiana.)

### The Huron Group.

(Synonyms: Chester, Kaskaskia, Archimedes, Pentremital.)

Counties in which the Huron group outcrops: Perry, Harrison, Crawford, Washington, Orange, Dubois, Martin, Lawrence, Monroe, Greene, Owen, Clay and Putnam.

Name.—The Huron group was first so called by Dr. Geo. H. Ashley in his report on the Lower Carboniferous area of Southern Indiana in 1902. Previous to that time it was known as the Chester or Kaskaskia from the localities in Illinois. The reasons for the introduction of the new term Huron in place of Chester are given in detail by Dr. Ashley, in the Twenty-seventh Annual Report, the principal reason being that the Illinois terms as originally used were more comprehensive and did not correspond with this remaining division of the Lower Carboniferous rocks in Indiana.

Description.—The Huron group name applies to the upper division of the Lower Carboniferous rocks comprising the limestones and sandstone and in some places the shale layers included

between the top of the Mitchell limestone and the bottom of the Mansfield sandstone and conglomerate. It consists generally of several alternating beds of coarse yellow sandstone and crystalline limestone.

It contains oölitic limestone in several places. The oölitic stone is local in occurrence, present in a few localities and not of very great thickness and extent. It is the true concentric oölite, consisting of concentric layers of calcite around a small grain of sand and hence structurally different from the Bedford oölitic limestone. It occurs in many localities in Orange and Lawrence counties. Intermingled with the sandstones and limestones there are beds of blue, gray, brown and black shales and clays with small deposits of coal. The coal varies from the merest trace up to three inches in thickness.

The exposure at the type locality in the rock cut on the railway a half mile east of Huron Station in Lawrence County, shows the following layers:

| | *Feet.* |
|---|---|
| Mansfield sandstone at top of hill. | |
| Huron limestone and shale group. | |
| Crystalline crinoidal limestone, 8″-10″ | 30 |
| Blue, compact, fossiliferous limestone | |
| Gray shale, 10′ | 35 |
| Compact limestone, 6″ | |
| Blue gray shale, weathering to yellow and red clay, 24′ | |
| Buff oölitic limestone, 8″ | 8 |
| Blue-gray shale, weathering to yellow brown clay, 15′-20′ | 15 |
| Compact evenly-bedded buff and blue oölitic limestone | 14 |
| Black carbonaceous shale with fossil plant remains | 3 |
| Yellow ferruginous sandstone and shale | 20 |
| Mitchell limestone at base of hill below the railway. | |

In Orange County Kindle divides the Huron ("Kaskaskia") into a lower limestone, a lower sandstone, a middle limestone, an upper sandstone and an upper limestone. Some of the sandstones are used for whetstones. The lower limestone is a compact, smooth-grained blue limestone. The middle limestone is a semicrystalline, gray fossiliferous rock. The upper limestone is gray colored with occasionally a pink tint. It is usually crystalline and in places it is composed largely of crinoid stems and Archimedes bryozoa. Locally there are thin bands of chert. The sandstones are described as buff to light gray or white, medium coarse grain, con-

taining limonite concretions and locally beds of shale, clay, and coal. The coal seams are from two to six inches thick.

Detailed sections of the Huron group in the vicinity of Leavenworth and other points in southern Indiana are given by Ashley in the Twenty-seventh Annual Report, pp. 74-77. These sections show a somewhat complex series of shales, limestones and sandstones.

The local variations in thickness of the different layers, and the rather rapid change along the outcrop, of sandstones to shales and vice versa, would throw considerable doubt on any correlation of the beds in the Huron group in different parts of the State that is based on the comparison of the sandstone and shale beds. The limestone beds in the series may be correlated over larger areas because they are much more persistent and widespread rocks and they carry more distinguishing features. For example, the limestones are more distinctly characterized by uniformity of color and texture and stratification, as well as having more and better preserved fossil remains than the sandstone.

In many places the top of the Huron group is marked by an erosion interval and the overlying group, the Mansfield, lies unconformably upon it.

Topography.—The area covered by the outcropping Huron group is characteristically hilly and broken. It forms a belt of rather conspicuous hills bordering on the west the broad rolling, rather flat area of the outcropping Mitchell limestone. In places the hills are low and rounded, but are generally quite steep with rock cliffs and talus slopes. Through western Lawrence, Monroe and Owen counties and in parts of Putnam these hills composed of the Huron sandstones, shales and limestones form a quite prominent feature of the landscape as one approaches them from the east over the rolling plain surface of the Mitchell limestone. The higher hills and the higher upland areas a little further west are capped by a bed of the durable Mansfield sandstone. Probably many of the Huron hills have had a protecting cap of the Mansfield until comparatively recently.

Distribution.—The Huron group has about the same northern limit as the Bedford limestone, but as it thins out gradually under the heavy mantle of glacial drift its exact northern limits are difficult to determine. In the Oldshoe limestone quarry, in the

southwest corner of Montgomery County, the upper portion of the rock quarried is thought to be the Huron group, and that is the most northern outcrop observed by the writer.

At Okalla Station, in Putnam County, there is an exposure of from two to five feet of Huron sandstone overlying the blue Mitchell limestone. Through the southwestern portion of Putnam the Huron sandstones and shales appear in large quantities and in continuous strata and become thicker and more prominent further south through Owen, Monroe, Lawrence and Orange counties, and thence on south to the Ohio River, as shown on the map.

Economic Features.—The sandstones and sandy shales of the Huron group are used extensively in Orange County for whetstones and grindstones. The center of this industry is in French Lick and West Baden, in the vicinity of which there are numerous quarries, and a few rude mills. Much of the stone is shipped in the rough to factories in other states.*

In several places the sandstone has been quarried for local use as a building stone. It is easily quarried and dressed and, if carefully selected, is very durable, so that it might have a more extended usage in this line.

The limestone makes good road metal and has had a limited use for that purpose. The character of the roads over much of the region is such as to cause one to wish that much more of the stone might be used for this purpose. For road-making the more compact layers are more desirable than the more highly crystallized ones.

Some of the limestone is suitable for building stone, but will probably never have an extended use for this purpose because of its proximity to the Bedford oölitic, which is a much better stone. The limestone has been used to a limited extent for making quicklime and might be used in much larger quantity for this purpose if the demand would justify it.

### Mansfield Sandstone.

(Synonyms: Conglomerate, Millstone Grit, Pottsville Conglomerate).

*Part of the whetstones and grindstones are obtained from the Mansfield sandstones. For particulars of the whetstone industry see the paper by E. M. Kindle in the 20th Ann Rep., 1895.

References—

Hopkins, 20th Ann. Rep., 1895, pp. 188-323.
Kindle, 20th Ann. Rep., 1895, pp. 329-368.
Ashley, 23d Ann. Rep., 1898.
Thompson, 17th Ann. Rep., pp. 30-40.

Mentioned in many of the other Annual Reports: See Index.

Counties in which it occurs: Benton, Jasper, Warren, Fountain, Montgomery, Parke, Clay, Putnam, Owen, Monroe, Greene, Lawrence, Martin, Daviess, Orange, Dubois, Crawford, Perry and Spencer.

NAME.—The Mansfield sandstone is the bed of coarse-grained sandstone and conglomerate that lies at the base of the Coal Measures. The name was first used in 1895 in the first report of the Blatchley survey and in the annual reports since that date. It is named from the typical exposure at Mansfield, in Parke County, Indiana. In the earlier reports it is called the "Conglomerate" in some places, the "Millstone Grit" in places, and farther east, in the northern Appalachian region, the Pottsville conglomerate. Owing to the uncertainties involved in correlating this formation with the Pottsville Conglomerate in Pennsylvania, and the still greater doubt in correlating with the Millstone grit of England, and the lack of definiteness in the term "conglomerate," it was thought best to use the local name.

The group is limited below (1) by an unconformity and (2) by the underlying Subcarboniferous limestones and shales. Its upper limit is the coal, shales, and clay beds of the productive Coal Measures, from which it is also separated by an unconformity.

The rock varies greatly in texture, color and thickness. In places it is a coarse conglomerate, brecciated at times, from which it grades into coarse sandstone by the decrease in the number and size of the pebbles and the corresponding increase in the relative amount of sand. It is in places a massive sandstone, but elsewhere more or less laminated, and in many places shows cross-bedding. Locally it contains many nodular iron masses which are generally hollow. It is not rich in fossils but in places it contains fossil coal plants and locally it contains small coal seams and beds of fireclay.

The color varies from light gray through buff, yellow, yellow-

brown to red. The yellow to yellow-brown color is due to the hydrous ferric oxide or limonite, and the red and red-brown color is due to the anhydrous ferric oxide or hematite.

Topographic Features.—The Mansfield sandstone is more durable than the underlying and overlying rocks, and hence it forms cliffs and rock terraces in many places. The map shows the position of many small outliers where the sandstone forms the cap rock of the limestone, or the limestone and shale, hills. It forms many bold cliffs along the water courses. It yields readily to the corrading action of the stream, but resists the action of the weather so that it remains in almost vertical walls, and thus impresses itself very strongly on the topography of the area where it occurs. The bold cliffs at the Shades of Death, at Turkey Run and at the Devil's Basin and many other places along Sugar Creek and its tributaries are formed by the Mansfield sandstone.

Geography.—The Mansfield sandstone appears to correspond in part at least with that widespread bed of sandstone and conglomerate that almost everywhere underlies the productive Coal Measures, forming a bed of coarse-grained siliceous material on which rests the clays, shales and coals of the Coal Measures. It marks a period of subsidence and inflow of the sea. Previous to this period there had been an elevation of the land and erosion had cut numerous valleys to varying depths. The incoming sea gathered up the fragments of rock waste and formed deposits over the newly formed or forming seabottom, filling all the depressions of the former land area, thus forming a mantle of sand, gravel, clay and coal, which rests unconformably upon the underlying uneven surface. Different kinds of deposits would be forming in different parts of the area at the same time, thus the advancing shore lines would, in many places, have quite violent waves in which the characteristic beach or straticulate structure would show itself in mixed deposits of sand and gravel more or less inclined to the horizontal, while out from the beach in the deeper water, deposits of fine sand and mud would be formed on which as they reached the surface would form swamps and bogs that later became coal beds. As yet such vegetable deposits were quite limited in both vertical and areal extent, in comparison with those formed in the succeeding period.

In the bottom portion of the deposit, as might be expected, the coarse basal conglomerate is more pronounced than higher in the stratum.

DISTRIBUTION.—The Mansfield sandstone outcrops over a broad belt extending from the northern part of Warren County east of south to the Ohio River. It has an almost continuous outcrop over part of the area. Because of its massiveness and relatively greater durability, it outcrops at the surface more than many of the other strata. It forms a dividing belt between the Lower Carboniferous limestones on the east and the coal producing beds on the west.

DISTRIBUTION IN OTHER STATES.—The coarse-grained basal conglomerate and sandstone underlying the Coal Measures occur quite widely distributed in this country and Europe. In eastern Pennsylvania it is known as the Pottsville conglomerate and consists of a very coarse conglomerate with white quartz pebbles an inch or more in diameter. In central and western Pennsylvania and in Ohio and West Virginia the rock consists largely of coarse sandstone, grading into quartz conglomerate in many places. In some places there are pebbles scattered through the sandstone.

This sandstone is probably one of the most widespread rock groups in the central and eastern United States, forming great siliceous basins underneath all the coal beds, one extending over a wide area along the Appalachians from New York into Alabama; another in Indiana and Illinois; another underlying the west-central basin of Iowa, Missouri, Kansas, Oklahoma and Arkansas, and another in central Michigan.

ECONOMIC FEATURES.—Coal occurs in the Mansfield group in several places, but in only a very few is it in sufficient quantity and quality to justify mining operations. The fireclay and shales have some local value, but, like the coal, not much, because of the superior quality and greater quantity in the Coal Measure rocks overlying.

The most important economic product in the Mansfield group is the sandstone suitable for building stone. It has been quarried and used for building purposes, as brown sandstone, at the following points: Hillsboro, Judson, Mansfield, Bloomfield and St. Anthony, and as buff or gray sandstone at Williamsport, Kickapoo, Attica and in small quantities for purely local use at many other points.

In many places the stone contains too many impurities or lacks homogenity of texture to fit it for good building stone, but locally, where it occurs free from the imperfections in composition and texture, it furnishes a stone of superior quality for building purposes. The stone is quite soft when first quarried but hardens on exposure, thus adding greatly to the ease with which it can be quarried and dressed. The most serious defect in it is the segregation of the iron oxide into nodules which both discolor and weaken it. That the Mansfield sandstone is a very durable stone is shown by the prominence of the outcrop, the numerous steep cliffs and rock terraces, and the many hills that are capped by it.*

Another important use of the Mansfield sandstone is for whetstones and grindstones. The center of this industry is French Lick Springs, in Orange County. In the hills surrounding French Lick the stone has been quarried and manufactured into whetstones and grindstones for many years.†

### Productive Coal Measures.

*Coal Deposits of Indiana.* By George Hall Ashley. 23d Ann. Rept. Dept. of Geol. and Nat. Res., 1898, pp. 1-1574.

See the above report for maps, illustrations, detailed description and bibliography of previous publications on the coal deposits of Indiana.

Counties in which the productive Coal Measures outcrop: Newton (?), Benton (?), Warren, Fountain, Vermillion, Parke, Vigo, Clay, Putnam, Owen, Greene, Sullivan, Knox, Daviess, Martin, Dubois, Pike, Gibson, Crawford, Perry, Spencer, Warrick, Vanderburgh and Posey.

Only a brief outline of the geology of the Coal Measures will be given here, since such a complete and detailed report was published so recently (1898). (See referenc above.)

Nomenclature.—In the older reports the coal beds are designated by letters of the alphabet, the lowest and oldest seam called A, the next one overlying, B, and so on up through the series. The more detailed survey, ending in 1898, attempted at first to

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*For its use as a building stone see Sandstones of Western Indiana, by T. C. Hopkins, in 20th Ann. Rep., 1895, p. 188.

†For its use as an abrasive, see Whetstones of Indiana, by E. M. Kindle, in 20th Ann Rep., 1895, p. 329.

continue this system, but they found such serious objections to it that it was thought best to abandon it. Mr. Ashley says: "1. We found about twice as many coal beds as the system, as applied, gave room for. 2. The application of the system to the coal beds found contained so many errors as to make the past application at great variance to our own."

In view of the difficulties involved in the old system of naming the coal seams, Mr. Ashley adopted a new system, which consists in dividing the strata of the Coal Measures into eight spaces and designating them by the Roman numerals, beginning with I at the bottom. Except the bottom division I., which is the Mansfield sandstone, and is separated by unconformity from both the lower carboniferous below and Division II. above, the divisions are based on the position of the principal coal beds, as found in northern Clay and Vigo counties. Divisions II. to VIII. each begins with a prominent coal seam and extends up to the bottom of the next prominent coal seam, and hence each division includes at least one coal seam, and also the other rocks, as sandstone, shale, limestone and clay, up to the next prominent seam, and likewise includes all the minor, secondary or local seams that occur in this space.

The classification of the coal seams and associated rocks is not so simple as that of the limestone strata of the preceding period, owing to the great many geographic changes that took place during the coal period. The work on the present survey brought out the following points in support of the above statement:

1. No single stratum of rock or coal in the Coal Measures, with possibly the exception of the basal sandstones, is persistent over the whole coal field, or even between the extreme points of its extent.

2. That, as a rule, the coal beds are a little more persistent than any of their accompanying rock strata.

3. That a thick coal bed is usually more persistent than a thin bed.

4. That the upper beds of the Coal Measures are usually more persistent than the lower, their accompanying strata also being more persistent than the strata accompanying the lower beds.

5. That often when a coal is lacking, the position of its horizon is shown by the accompanying strata.

6. That the horizon of certain coals can be traced persistently, if time and detailed study be given to it.

These points illustrate the fact that was not and is not appreciated by many, namely, that most coal seams, as well as the strata associated with them, are necessarily more local in their occurrence than are the thicker strata of purely marine origin. Conditions are more uniform over the sea bottom than over a land area, especially a swamp area, such as the Carboniferous coal fields. As these areas were subject to many periods of elevation and depression during the accumulation of the carbonaceous deposits that form the coal beds, there would from necessity be many swamp, lake, sea and land areas. While it is possible that a vegetable swamp might have extended over the entire Indiana-Illinois coal field, it is much more probable that over such a large area so near sea level, there would be portions of the area under water too deep for vegetation to grow, and other portions above the water where no vegetation would accumulate. Hence, the coal would form either in separated basins or in one large basin, with many barren spots, where the land areas and the deeper water areas were at the time. It should be kept in mind that many coal seams cover only a few acres, or a few hundred acres, while others may extend over hundreds, or even thousands, of square miles.

Division I. of the Coal Measures has already been described under the heading of the Mansfield sandstone. The coal that occurs in this division is in small seams and of quite limited extent. Over a large part of the area covered by the sandstones and shales of Division I. there is no coal at all.

The correlation of the other divisions, II. to VIII., over the coal area is attended with difficulty and often with uncertainty, as one gets away from the type locality where it was named. The correlation of a coal seam in the northern part of the field with one in the southern part is from necessity attended with uncertainty where it can not be traced across the intervening area or associated with some stratum above or below it that can be traced over the entire area. As the twenty-third annual report gives a detailed description of the entire area, any one by consulting the maps and text of that report may determine the stratigraphical position of any coal seam almost anywhere in the area.

VARIETIES.—Of the two great classes of coal, anthracite and bituminous, only the latter occurs in Indiana. Anthracite coal is harder than bituminous and contains less volatile material and a higher percentage of carbon than bituminous, and is commonly supposed to be derived from bituminous by the loss of most of the volatile material. Bituminous coal is commonly divided into two classes, *coking* and *non-coking,* both of which occur in Indiana. The coking coal, when heated, melts and runs into a coke, while the volatile material passes off as gas. It is the kind commonly used for the manufacture of artificial gas, and the coke is then a by-product. Where it is used for the manufacture of coke, the gases may or may not be saved. *Cannel* coal is a variety of bituminous that is hard, very compact, and has a dull lustre, resembling black shale. It generally has a higher percentage of volatile matter and kindles easily, and burns with a bright yellow flame. It is a good gas coal when mixed with a coking coal, and it is also a very desirable grate coal, because of its bright yellow flame.

*Block* coal is a variety of bituminous that splits readily in thin sheets parallel to the bedding, but breaks across the bedding with great difficulty. It burns freely without coking. It makes a good grate coal and is the only bituminous coal that can be used successfully in the blast furnace without coking. The block coal occurs abundantly at Brazil and vicinity in Clay County. It occurs in basins from a few acres to several miles in extent, and is found mainly between Raccoon Creek, on the north, and Eel River, on the south. It is found mainly in Divisions III. and IV. of Ashley's classification.

MEROM SANDSTONE.—*Division IX.*—The productive Coal Measures in Indiana occur between two great beds of sandstone. The Mansfield sandstone, at the base, is included in Division I., and overlying all the other strata is the heavy sandstone of Division IX., classed as the Merom sandstone, from the village of that name in western Indiana. It appears to rest unconformably on the underlying Coal Measures, and contains a basal conglomerate in many places. In the northern portion of the area it fills deep erosion channels in the Coal Measures. There is some doubt as to the stratigraphic position of this sandstone. No fossils have been reported from it in Indiana, but it is thought that it probably

corresponds stratigraphically to the Triassic period, as indicated by fossil forms from Illinois.

Occurrence and Distribution.—The boundaries of the Coal Measures on the large State map are the same as on the larger scale sheets accompanying the coal report, but the subdivisions are different. Because of the necessarily smaller scale where the whole State is represented, the Coal Measures are divided above the Mansfield sandstone into three parts. The lowest division which lies immediately west of the Mansfield sandstone outcrop includes the block and semi-block coals. The next division, which overlies this and outcrops west of it, includes the coking coals and the upper division includes the Merom sandstone. These areas are separated on the map by light dotted lines similar to those separating the other groups, but the different divisions are not distinguished by separate colors.

As may be seen on the map, the Coal Measures cover nearly a third of the State. Coal occurs and has been mined in the following twenty-three counties: Warren, Fountain, Montgomery, Vermillion, Parke, Putnam, Clay, Vigo, Owen, Greene, Sullivan, Knox, Daviess, Martin, Orange, Crawford, Dubois, Pike, Gibson, Perry, Spencer, Warrick, Vanderburgh and Posey. Of the above the following six counties, Montgomery, Putnam, Orange, Crawford, Vanderburgh and Posey, produce such a limited quantity of coal that they could hardly be classed in the commercially productive area.

In 1898 there were 852 mines in operation, of which 731 employed less than 10 men, and 123 employed ten or more men in each. In 1881 there were 4,567 employes producing 1,771,536 tons. In 1891 there were 6,975 men producing 3,819,600 tons, and at the end of the next decade in 1901 there were 12,096 men producing 7,019,203 tons.

### Pleistocene. (Quaternary.)

About the close of the Carboniferous era the Indiana area was elevated above sea level, and has remained so since that time. It was subject to the action of the eroding agencies during all the long Mesozoic and Cenozoic times, since there is no evidence of any subsidence below sea level during that very long interval.

Early in the Quaternary or Pleistocene period there was a change in climate from a condition warmer than the present to one colder than the present. As the climate grew colder over North America the snow began to accumulate in the Canadian Highlands. More snow would fall than would be melted during the year, so that there was an accumulation on the upland. Probably just as at present this snow would become granular ice, and then compact blue ice, and as it accumulated it would flow away in sluggish streams from the center. This Pleistocene glacier was so large that it flowed out from the Canadian uplands as a great sheet of ice, hundreds, in places thousands, of feet in thickness, that spread over all the northern United States. It covered a large part of Indiana, extending nearly to the Ohio River in the southeastern and southwestern parts of the State, and in the central portions as far as the southern part of Owen County.

This vast sheet of ice had a very marked effect on the area over which it passed. It eroded the rocky surface, grinding it off in great quantities, but more in some places than in others. It also carried in from northern regions a great supply of boulders, and mineral and rock material and moved forward varying distances vast quantities of local material. When the glacier finally disappeared the rock material that was in and on the ice would be deposited and often in quite irregular masses.

One of the direct effects of the glacier was the formation of a great number of lakes. Some were formed in depressions in the rock which were gouged out by the eroding ice; others were formed by the deposition of earth across a valley, forming an earth dam; still others were formed by water accumulating in the depressions formed by the irregularities in the mantle of glacial debris. There are tens of thousands of these lakes over the Northern United States, and several scores of them in northern Indiana.

Another marked effect is the heterogeneous character of the soil-covering, which for the most part is more productive and valuable than the original soil.

Another effect is the general leveling of the area. In a few places the moraines or the deep erosion by glacial streams may tend to roughen the surface, but for the most part the opposite effect has been produced, as the grinding action of the glacier tends to wear off the sharper ridges and the deposit of the material carried

by the ice tends to fill up the deeper valleys. Northern and central Indiana probably has a much more regular and even topography and a much more fertile soil than it had before the glacial period.

The great masses of gravel deposited by the glacial waters furnish an excellent road metal. These gravels have been widely distributed and widely used over the glacial region of the State, and so far as they have been utilized judiciously better roads have been the result.

Besides earth, clay and gravel, the glacier carried many large boulders, and in some places these large boulders have been left in lines, known as boulder trains, which extend for many miles across the State. Along the line of these boulder trains the rocks are so numerous and so large in many places that it is not possible to till the soil.

The Pleistocene glacial period has been referred to in the singular number, but it should be noted that the studies of recent years seem to indicate that there were several recessions and advances of the glacier and the periods between the recession and the next advance may have been quite long; long enough, it is thought, in some instances, to permit extensive forest growth. It has been a question of dispute for some years as to whether these different advances of the ice should be considered separate epochs or only stages of the same epoch. In the Mississippi basin area the deposits have been subdivided into nine parts, named in order beginning with the bottom or oldest bed as follows: 1. Albertan Drift Sheet. 2. Aftonian beds, interglacial. 3. Kansan Till Sheet. 4. Buchanan interglacial deposit. 5. Illinois Till sheet. 6. Interglacial deposit (not named). 7. Iowan Till sheet. 8. Toronto (?) interglacial deposit. 9. Wisconsin Till sheet.*

*See Journal of Geology Vol. IV, 1896, and Vol. II, 1893.

# THE PETROLEUM INDUSTRY IN INDIANA IN 1903.

By W. S. Blatchley.

Definition of Petroleum.—Crude petroleum, or "rock oil," is a natural bitumen, composed mainly of the combustible elements, carbon and hydrogen. In its most common form it is a brownish-black, ill-smelling liquid, with a specific gravity of about .86. When kindled, it burns readily with a bright flame and without leaving a residue. When exposed to the atmosphere it gives up slowly its volatile gases, and is, in time, reduced to a thick, semi-solid, asphaltum-like mass. The name petroleum comes from two Latin words, *"petra,"* a rock, and *"oleum,"* oil, and in many localities it is known as "rock oil," or simply "oil."

Distribution of Petroleum.—Petroleum is widely distributed throughout the countries of the world, and is found in the rocks of almost every geological formation, from those of the old Archæan time up to the later members of the Tertiary Age. In some of the older countries, as India and Japan, it has been known to and used by man as a remedial agent for more than 2,500 years. For many centuries, however, its uses were few, its possibilities of furnishing valuable products by distillation not being known. With the advancement in the knowledge of chemistry came a better understanding of its component elements, and within the past quarter of a century it has come to be one of the great and necessary resources of the earth. Its value has fluctuated from time to time, but since 1900 the tendency has been upward, for the demand has come to exceed the supply. For a year or two the refiners have been using the crude oil faster than it is being pumped into the pipe lines, and the reserve stocks of millions of barrels in the great iron tanks have been called upon to supply the deficiency.

During the year 1902 the United States produced 80,894,590 barrels of petroleum, which brought, delivered into the pipe lines,

$69,610,348. In the same year Russia produced 80,493,381 barrels. The United States thus stood first in the rank of petroleum producing countries, and, aside from Russia, produced more oil than all the rest of the world combined.

The oil from the different parts of the United States varies much in character and grade. That from Pennsylvania, New York, West Virginia and southeastern Ohio, known as "Pennsylvania Oil," is considered best for making illuminating products, and brings the highest price on the market. The "Lima Oil" from the Trenton rocks of northwestern Ohio and northeastern Indiana ranks second in grade. Like the Pennsylvania oil, it possesses a paraffine base, but contains a certain percentage of sulphur, not found in the former, and for that reason is more expensive to refine. The oils of Kansas, Colorado and Corsicana, Texas, have also a paraffine base, and rank about equal with the Lima oil in value. Most of the petroleum produced in Louisiana, Texas and California has an asphaltum base, and consequently yields an illuminating oil of low value. It is used largely for fuel and brings a much lower price per barrel than the oils with a paraffine base.

While the increase in petroleum production in the United States in 1902 was 11,505,396 barrels, the great percentage of gain was in the low grade oils of California and Texas. The high grade Pennsylvania product decreased 1,646,651 barrels, while the medium grade Lima output increased 1,425,247 barrels, all of which came from new developments in Indiana. During that year the accumulated stocks of Pennsylvania and Lima oils were decreased 4,175,173 barrels. In other words, the supply of high and medium grade oils throughout the year averaged 11,000 barrels a day less than the demand. For that reason the price rose gradually in 1902, and again in 1903, when the shipments of Lima oil exceeded the output of the wells by 3,780,288 barrels. At the present writing it is the opinions of experienced oil operators that the price of the better grades of crude petroleum will not soon, if ever, fall below the dollar mark. The prospects for any increased output of the paraffine oil production of the United States are being gradually narrowed down each succeeding year. At the same time there has been a constant increase in the demand

for all classes of products that are manufactured from the higher grades of petroleum, with no indications of any immediate change.

USES OF PETROLEUM.—The average person has but little knowledge of the many uses to which crude petroleum is put or of the variety of products made from it in the great refineries. The most important and best known of these products is, of course, the illuminating oil known as kerosene, or "coal oil." This oil has become one of the greatest adjuncts of modern civilization; in fact, such a necessity of daily life that millions of inhabitants of this and other lands would find it difficult to do without. Besides kerosene, all the gasoline, benzine and naphtha of commerce come over as distillates from the crude petroleum. Among the solid products are vaseline, used so extensively as an external application, and paraffine, the candles of which have almost wholly superseded the old tallow "dip." Much paraffine is also used in making matches; as a preservative for eggs and various food stuffs; in laundry work as an auxiliary to soap, and for many other purposes. Rhigolene, a volatile product of crude petroleum, is a valuable anæsthetic, particularly for local application to produce cold.

Both petroleum products and crude petroleum are much used in the manufacture of artificial gas. In the making of "air gas," or carburetted air, gasoline is needed, while for "oil gas" and carburetted water gas crude petroleum is used, the liquid hydrocarbons of the oils being converted into permanent gas of high illuminating power. The crude petroleum is also often used for the enriching of coal gas., i. e., for making it of higher illuminating power.

Mineral oils from petroleum and the crude product itself are now almost wholly used for lubricating machinery, especially railway engines. As noted above, the poorer grades of crude petroleum, especially those with an asphaltum base, are extensively used as fuel.

In the words of the superintendent of one of the leading refineries of the country: "Practically nothing is now allowed to go to waste. Our by-products are really more valuable than the refined oil itself. Benzine and gasoline, which were formerly not considered by us, are now very valuable commodities. The coke which results from the burning of crude oil was formerly dumped into the river; now it is used in the manufacture of the carbons

for electric lights, and we can not get enough of it. The vapors arising from the oil are condensed and recondensed, and are added to our list of by-products. In fact, nothing is permitted to get away which can, in any manner, shape or form, be utilized, and this is ascertained by our chemists and inventive men.

"There is not a thing designed or invented that will aid us either in our manner of refining the oil, or in effecting a saving so that we can utilize what was formerly wasted, that we do not have in our refineries. The changes that have taken place in the last ten or fifteen years are simply wonderful. Take refined oil, for instance. Many of our people can easily recall when it was almost as yellow as saffron; now it is as clear as crystal, and has been refined to such a degree that not a drop of it need be wasted. Our oils are used in soaps, perfumes, liniments, vaseline, and in so many different ways that I have neither the time nor the inclination to try to define their varied uses."

Petroleum in commercial quantities was first produced in Indiana in 1889, in a well put down by the Northern Indiana Oil Company, on the D. A. Bryson farm, near Keystone, Chester township, Wells County. From that date until January 1, 1904, the industry has gradually grown, until it has become one of the greatest in the State. From 33,375 barrels, valued at $10,881, in 1889, the output has increased to 9,177,722 barrels, valued at $10,476,369, in 1903. That the yearly output depends largely upon the price, and not upon the capacity of the field, is shown by the fact that the years 1897 and 1898 were the only ones, since the striking of oil in the State, in which the production fell off, and during those years the price was low, ranging only between 40 and 60 cents per barrel. Since 1898 there has been, for the most part, an upward tendency in price, and as a result the output has nearly trebled.

Petroleum in commercial quantities has been found in three distinct geological formations in Indiana, viz., the Trenton limestone of the Lower Silurian Age; the Corniferous limestone of the Devonian Age, and the Huron sandstone of the Sub-Carboniferous Age. It is, however, from the Trenton limestone that the great bulk of the crude petroleum of the State is produced. Each of these formations will now be taken up in order and its petroleum output treated.

## TRENTON ROCK PETROLEUM.

FORMATION OF THE TRENTON LIMESTONE.—The Trenton limestone is one of the lower or older formations of the Lower Silurian System. Like other limestones, it owes its origin mainly to the presence of minute organisms in the water in which it was first laid down. The animals from whose remains the oil of the Trenton limestone was, for the most part, derived, were probably very low forms—the polyps and bryozoans of the ancient Silurian seas. In untold numbers they existed, and the carbonate of lime which makes up 80 per cent. of the unmodified Trenton rock is largely the remains of their secretions and incrustations. Associated with these lower forms were myriads of higher ones—crinoids, brachiopods, trilobites, gastropods, and even fishes. The presence of such swarms of animal life made necessary the existence of an abundance of plants, since the plant must ever precede the animal and gather for the latter the energy, and form for it the food, the living protoplasm, necessary to its existence. These plants were mostly marine algæ, or seaweeds and fucoids, though doubtless many other forms existed of which no remains have been preserved in the rocks of that age.

The Trenton limestones were evidently formed in rather clear water, at moderate depths. Near the bottoms of these shallow seas great beds of calcareous sediment were gradually collected, and were swept to and fro by the tides and currents. Rivers from the older Cambrian rocks brought down their eroded particles and added to the thickness of the ocean floor. Within these beds of sediment both plants and animals found a grave, their bodies in vast numbers being buried beneath the slowly accumulating deposits of centuries. Once buried in such deposits, they did not decay, as do animals on land, because by the waters above and the calcareous ooze around them they were shut off from free oxygen, which is the chief agent in decay. Gradually this ooze or fine sediment was, by the agency of the sea water, cemented and consolidated into limestone. In this manner that great layer of Trenton rock, which underlies at variable depths the whole of Indiana, was formed. From it has been derived, directly or indirectly, more wealth than from any other formation either underlying or forming a portion of the surface of our State.

ORIGIN OF PETROLEUM.—In time the waters of the ocean containing this vast stratum of Trenton limestone, with its enclosed accumulation of undecayed plants and animals, became turbid, and, instead of calcareous sediment, deposited mud and clayey sediment in thick beds on top of the limestone strata. These deposits of mud and silt were afterward, by later deposits, compressed into the fine grained, impervious Utica shale, 100 to 300 feet in thickness, which thus effectually sealed the Trenton limestones, and so retained within them the oil and gas derived from their enclosed organic remains. This oil and its more volatile portion, the natural gas, was probably not formed in a short time, but is the result of a slow decomposition or destructive distillation carried on through thousands of centuries. Accumulating in vast reservoirs, the more porous portions of the Trenton limestone, or mother rock, it there remained until man came with his iron drill and furnished a vent through which it could rise. Then by combustion he caused it to yield up the stored energy, conserved since the sun's rays fell on the plants of the old Silurian seas.

ORIGIN OF NATURAL GAS.—From what has been said, it will be seen that both natural gas and oil have a common origin, viz., the destructive distillation, carried on through thousands of years, of the plants and animals which existed in the Trenton Period. It is a well known fact that if wood, coal or the body of any animal be placed in an air-tight retort and heated, a distillation will occur, and the object will be changed to gaseous, oily and solid matters. In the absence of heat and air a very long period of time will bring about the same results. By this is meant the process of "slow destructive distillation" above mentioned. The primary product of such distillation was probably a light oil, which in the course of ages has, by volatilization, yielded the gas, and has itself been condensed into the heavier petroleum. The gas being lighter and more volatile than the oil, gradually rose into the higher interstices of the limestone. If an open barrel be filled with crude petroleum from the Trenton limestone of Indiana and exposed for a single summer to the air, more than half of the contents will pass away in the form of a vapor, and a sticky, tar-like residue will remain. If by some means the escaping vapor could be collected and analyzed it would be found in the main to have the same composition as natural gas. In fact, it would be natural gas, and

would burn as freely as a sample of that valuable fuel, collected in the ordinary way. In the depths of the rock the evaporation of the oil has been extremely slow, and the amount has been limited both by the varying pressure of the overlying gas and the underlying water. There is little doubt, however, but that all the natural gas of the Trenton limestone has been so derived.

DISTRIBUTION OF PETROLEUM IN THE TRENTON LIMESTONE.—Not only Trenton limestones, but every other limestone, as well as most shales, have in the past produced petroleum in greater or less quantities. Distributed in minute proportions through the substances of the rocks, it easily escapes notice, but when intelligently looked for its presence is revealed, and, though the percentage is small, the aggregate is often vast. If, for example, a stratum carries but one-tenth of one per cent. of petroleum and is 500 feet in thickness, it contains more than 2,500,000 barrels to the square mile. Indeed, so common is the occurrence of petroleum in stratified rocks that wherever a close-grained shale occurs there is almost always a small accumulation of oil directly underneath it. The same thing is found when an impervious stratum of any other composition than shale occurs in the geological series.

If petroleum has been thus generally formed throughout the Trenton limestone, why do not all parts of that formation yield it in somewhat equal amounts? Why is it that a bore that pierces the Trenton in one locality is a "dry hole," while another, but a short distance away, results in a "hundred-barrel" well? The answer to such questions lies in the fact that the formation of large accumulations of oil depends as much upon the presence of suitable strata to receive and retain them as upon an adequate source of supply. In the minutely diffused state in which the oil was originally formed it was wholly without value. Like all other forms of mineral wealth, it had to be concentrated into reservoirs, the so-called "pools" of the oil field, before it could be utilized by man. The thousands of bores put down to the Trenton limestone for oil and gas in both Ohio and Indiana have proven that four conditions are necessary before an accumulation and preservation of oil in commercial quantities can take place. If any one of these conditions is absent, a dry hole or salt water well will invariably result. These necessary conditions are:

1. A porous stratum of the Trenton rock to form a reservoir.

2. An impervious cover above the reservoir.
3. An arched or anticlinal structure of the rock in which the reservoir is located.
4. A pressure behind the oil to force it into the reservoir.

1. *The Porous Portions of Trenton Limestone.*—We have seen that the Trenton limestone is a sedimentary rock; i. e., one which was laid down in water, the bottom of the sea, ages ago. When first formed it was a nearly pure calcium carbonate or carbonate of lime. In the course of time certain areas of the sea bottom, covered with the incipient limestone, were slowly raised until they became higher than the others, and formed shallow basins, lagoons or bays. Some of these raised portions covered very large areas. Others were isolated or separated from the main area by a distance of one to 30 miles. The outline of all was irregular, with many indentations along the margins. In these more shallow portions of the Silurian seas the water became in time very briny and caused a chemical change in the rock. To the lime carbonate was added some magnesia from the brine, and a magnesia-lime carbonate called "dolomite" resulted. Wherever this change took place, which was only in the shallow, briny areas noted, the resulting dolomite was porous. This porous condition was due to the fact that the new crystals of dolomite were smaller than, and never entirely filled the spaces occupied by, the older crystals of lime carbonate. *The larger areas of the Trenton limestone deposit beneath the present bounds of Indiana were either too impure to admit of a change into dolomite, or the conditions of sea level were never such that the change took place; hence they are nonporous and barren of either oil or gas.*

Even in rich oil fields the porous dolomite has only been formed in a small proportion of the thickness of the Trenton rock. Usually two or more "pay streaks" or porous strata are found in the upper 70 feet of the Trenton. The upper one of these has a thickness of 3 to 10, or sometimes 15 feet, and usually occurs within 30 feet of the top of the Trenton. If the level of the Trenton is low at the point where the bore is put down, the upper streak is often lacking. The second porous stratum, usually the most productive, lies about 15 to 20 feet below the first and is separated from it by a bed of unchanged, nonporous limestone. This alternation of dolomite and limestone strata is probably due to changes in the

sea levels at the time the limestone was being transformed into dolomite. Wherever the Trenton limestone assumes its normal character and ceases to be dolomitic, it ceases also to be oil-bearing. The change from an area containing porous rock into one wholly lacking it, is often abrupt. It is only the former which contains the oil, and there is no known method, except by drilling, of determining where the porous rock occurs.

2. *The Impervious Cover.*—In order to properly retain the accumulated petroleum the porous rock must be entirely covered with an impervious stratum, i. e., one through which neither oil nor its volatile gas will pass or can be forced by the enormous pressure behind it. Such a cover is usually a fine-grained shale, and wherever such a stratum covers a porous rock, petroleum in greater or less quantities is usually found. In the Indiana oil field the Trenton rock is covered by an average thickness of 250 feet of that dark brown, close-grained deposit known as the Utica shale, which possesses every quality of a typical impervious cover. The driller recognizes this stratum as soon as he strikes it by its color, its comparative freedom from fossils, and the ease with which it is drilled and mixed with water. No free oil is found in the Utica shale, though by distilling portions of it an amount equal to three per cent. of the shale* has been obtained.

3. *The Anticlinal Structure.*—The surface of the Trenton limestone is not level as many people suppose, but, like the surface of the earth, is a series of alternating arches and depressions or ridges and valleys. The arches or domes are like inverted troughs and vary much in width and area, as do also the depressions between them. Wherever gas and oil occur they will be found in a porous stratum in one of the arches or *anticlines*, as they are called. If a bore happens to be put down and strikes a depression or *syncline* between the arches, salt water will invariably be found. If both gas and oil are present in a certain area, and the bore strikes the flank or side of the arch, oil will result. If the bore strikes the crest or dome of the arch, gas will flow. The cause of this is simple, being due to the arrangement of the three fluids according to their relative weights. When the oil was first formed, it was pushed or carried hither and thither by the heavier salt water be-

*Dana, Manual of Geology, 4th Ed., 522.

hind it. Much of it was carried away by the water and lost, but wherever one of the porous areas existed in the side or top of an anticline, the oil was carried into it and there remained. During the ages which have elapsed much of the oil was changed into a volatile gas, which rose into the higher porous portions of the anticlines or ridges of the Trenton limestone. As this gas accumulated, it pressed back the remaining oil into the sides or flanks of the arch. The oil being lighter than the water, rested upon the latter and prevented it from rising into the higher porous portions of the limestone. When a bore is put down and strikes gas the latter will flow until the quantity which is stored in the porous area of the anticline is exhausted, when the oil, if any be present on the flanks or lower portions of the porous stratum, will rise in the gas well. It may be that the oil has been carried by the salt water into the porous portions of another anticline, and that only salt water occurs beneath the gas. If this be true, the water will fill the porous reservoir as soon as the gas is exhausted. The anticlines vary much in size, their domes running from scores of miles down to a half mile or less in width. The gas in the higher part of each anticline is, therefore, often shut off from that in a neighboring anticline by the intervening oil or water, or both. In the same way the oil in an anticline which contains oil only may be shut off from that in another anticline by the salt water filling all the porous portions of the syncline between. It often happens that a gas bore is put down which strikes the crest of a narrow anticline or raised portion of Trenton limestone which has not before been pierced. As a result the so-called rock pressure of the gas is at first high, but rapidly declines on account of the small size of the anticline. All the wider and higher anticlines in the main gas field in Indiana in which porous Trenton occurs, have been pierced many times, and the stored gaseous product has become almost exhausted.

In the Indiana oil field the production of a new well can usually be foretold by the depth at which the top of Trenton rock is found. If it is from five to ten feet higher than the average in the nearby productive wells, the chances are that it will yield much gas and little oil. On the other hand, if the Trenton is struck ten to fifteen feet lower than the average, the bore has pierced a trough or syncline, and a salt water well usually results. Sometimes, how-

ever, there are apparent exceptions. Of two wells in which the Trenton is found at the same depth, one will be a "gusher," and the other, but a short distance away, a "dry hole." The only explanation which can be given in such a case is that the latter has pierced a close-grained or nonporous area of the Trenton, into which no fluid has found its way.

4. *The Pressure Behind the Oil.*—Whenever the drill pierces a stratum of porous rock containing oil, the latter is pushed upward by the so-called "rock pressure" behind it. Sometimes this pressure is so great that when the oil stratum is reached the boring tools are expelled from the drill hole, and the oil escapes in a fountain, rising high above the derrick, much of it being lost before the flow can be controlled. In most instances, even if the well proves to be one of small production, the oil is forced upward several hundred feet in the drill hole. As noted above, this rock pressure has, in the past, had much to do with the accumulation of oil in the porous reservoirs.

It is now almost universally admitted that the rock pressure in any oil field is nothing more or less than water pressure, as in artesian wells, the water entering the Trenton limestone at some point where the latter outcrops and so forming a head or source. Hence, the deeper the well, the greater the head of water and the higher the rock pressure. The porous rock contains a limited amount of oil, held in place by the overlying shale. The salt water is below this oil, ever pressing it upward into the vent furnished by the drill hole. As the supply of oil is gradually lessened, the water rises to fill the pores, and the rock pressure is lowered. The pressure does not tell us anything about the volume or amount of oil stored in the rock; but the rate of diminution of pressure furnishes an excellent index of the rapidity with which that amount is being lessened. When the supply of oil is exhausted, as it naturally will be in time, there is no source from which it can be renewed. The salt water will rise and occupy the space which formerly held the oil and it will come to stay.

Salt water also occurs in the Trenton rock in all portions of the Indiana field. Usually a difference of only six to ten feet in the elevation or depression of the surface of Trenton defines oil and salt water territory. If the well has been located over a syncline, or trough, in the Trenton, salt water is apt to be found before the

drilling has proceeded very far into that formation, and a well yielding only salt water usually results. If, however, the bore pierces the dome or flank of an anticline, either gas or oil will be struck, and the operator is usually careful to see that the drilling is stopped before the level of the water producing rock is reached.

In some cases, however, both water and oil are found together in the same stratum. Some of the best wells in the Indiana field are big salt water wells, pumping from 150 to 700, or even more, barrels of salt water, and 40 to 150 barrels of oil daily. It costs much more to operate a well of this kind, as it has to be pumped with a beam and, therefore, requires a separate power. Such wells

Fig. 1. D., Drift. N., Niagara limestone. H. R., Hudson River limestone. U. S., Utica shale. T., Trenton limestone. A., anticline. S., syncline. a to b, gas bearing stratum. b to c, oil bearing stratum. c to d, water bearing stratum of porous rock. e, preglacial channel through Niagara limestone. f, non-porous Trenton limestone.

Wells, Nos. 1 produce gas; Nos. 2, oil; Nos. 3, salt water; No. 4, dry hole; Nos. 5, oil and salt water.

are usually longer lived, as the salt water seems to renew the quantity of oil by bringing it in from quite an area of the porous stratum which the bore has pierced. Moreover, the salt water seems to keep the pores of the oil rock free from paraffine and other materials which have a tendency to clog them up, and a well producing four or five barrels of water a day in connection with the oil, is preferred by many operators to one that produces oil alone.

The accompanying illustration (Fig. 1) will probably lead to a better understanding of the above mentioned facts regarding the accumulation and preservation of petroleum in the "Trenton rock" fields of Indiana.

NECESSITY OF ACCURATE SURFACE LEVELS.—The trend, width and dip of the anticlines and synclines in the top of the Trenton limestone in any locality can only be ascertained by an accurate determination of the surface levels between a number of wells. Where a bore for petroleum has resulted in a good producing well, the level of the surface of the Trenton rock below tide should be carefully ascertained. This can be done only by running a transit level from the nearest point where the surface level is known, usually on a railway, to the site of the bore. By subtracting the surface level of the bore from the depth at which Trenton limestone is first struck, the surface level of the latter will be obtained. In but a few places in the State is the top of Trenton found above sea level. Where so found the depth to Trenton will be less than the surface level of the bore, and should be subtracted accordingly.

For example, the surface level at one point (*a*) near Hartford City is 894 feet above tide and the depth to top of Trenton 969 feet. The latter is, therefore, 75 feet below sea level. At another point (*b*), a short distance away, the surface level of the bore is 890 feet and the depth to Trenton 968 feet. At this bore the top of Trenton is therefore, 78 feet below tide, or three feet lower than at (*a*). The dip of the Trenton is, therefore, from *a* to *b*. The bore at *a* yielded much oil; that at *b* much salt water and little oil.

The location of the first half-dozen or so wells in any area a mile or two square must of necessity be largely a matter of guesswork, but if the surface level of the Trenton in each bore, productive or dry, be carefully ascertained, the trend of the anticline and the approximate limits of the field or pool can be soon determined. Too much guesswork concerning the surface level of the spot on which the well is located has been done in the past. In a broken country it is difficult for any man to guess approximately at the relative levels of two points a quarter of a mile apart, and the new level should always be ascertained with instruments. Of course the surface level of the bore has nothing to do with the absolute

height or surface level of the Trenton, or the absence or presence of the petroleum, but it has a great deal to do with the *accurate determination* of the surface level of the Trenton, and therefore with the location of future wells. If a few thousand dollars had been spent in Indiana in past days in the careful determination of surface levels, it would have saved a few hundred thousand which have been sunk in dry holes.

Pools Not Necessarily Connected.—A fallacy which is held by many would-be operators in the Indiana field is, that oil fields or pools run in lines, and that one field is connected with all others, the oil flowing from one to the other through a continuous strip of porous rock. This may in part be true in the Pennsylvania oil regions, but it is wholly untrue in the Trenton limestone area of Ohio and Indiana. While all the so-called "pools" of that area are found in the anticlines in the Trenton formation, they are not necessarily connected, nor do the anticlines run in straight lines. From what has been said about the origin of the porous areas of the Trenton limestone, it will be seen that a pool may be of any shape, and may lie in any direction from any other pool. Its boundaries may be straight or sinuous; its area one square yard or one thousand square miles. If the conditions necessary for the storing of petroleum, namely, a porous reservoir, located in the flank or dome of an anticline of the Trenton limestone, with an impervious cover above it and a water pressure below it, have been present in the past, the oil will very likely be found, whatever the shape, size or relative location as to other similar reservoirs. If any one of these conditions is lacking or has been lacking, the bore is sure to be a dry hole. Inasmuch as the top of the Trenton limestone in the main Indiana field is everywhere from 700 to 1,100 feet below the surface, it will be seen that the problem of locating in advance a paying well is a most difficult one.

Condemned Territory.—During the first few years of drilling for oil in Indiana much territory was needlessly condemned by isolated bores which were dry or very small producers. The average operator, then, as now, was in search of "gushers" or big wells, and turned down in disgust any territory where wells came in for less than ten barrels. With but little knowledge of the conditions governing the accumulation of oil it was thought that a dry hole condemned a square mile or more of the area about it. Experience,

gained by the sinking of thousands of bores, has, however, proven that "one well is a test for but one location," that is, for an area of but a few acres about the bore. As a result, much of the condemned territory has been redrilled, and, in most instances, good producing wells have been developed where at one time it was thought no oil existed.

When oil was but 40 to 60 cents a barrel it did not pay to pump wells which averaged only three barrels a day. Now that the price has risen to $1.30, wells which yield but one barrel are pumped with profit, provided a number of them are operated by a single power. In a number of places leases have been abandoned as non-productive or as not paying the cost of operating, and have since been taken up by new parties and found to be very productive.

Examples of such leases are near Montpelier, Blackford County, where in section 3 Harrison township, the Baltes Oil Co. is operating a lease on which nine small wells had been drilled and abandoned up to 1900. In 1903, three new wells were drilled which averaged 30 barrels each at the start. On the Miller lease just north of Montpelier, four wells were pulled out in 1899 and the lease abandoned. It was retaken and three new bores sunk in 1903, all of which are fair producers. Still a third example is that of the Penrod and Hart leases in section 19, Washington township, Blackford County. These were held for some time by the Fort Wayne Gas Co., but only small producers were obtained and the leases and power house were finally sold for $350 to Miller & Davenport, of Bluffton. The new owners, at a cost of $1,400, put down a well on the Penrod farm which made two tanks of oil in 14 days. This brought $356, or more than the original cost of the property, and they then sold the leases and well for $15,000, after owning it but 42 days. The last owners have sunk two additional paying bores, and are well pleased with the property. These are but three examples of scores that could be given. They go to show that the operator in the Indiana oil field is taking chances with every bore he sinks. He has no way of knowing beforehand what the results will be. He may pierce the center of a reservoir and get a 300 barrel well; he may strike near its outer rim and get a 10 barrel well; he may miss it altogether and get a dry hole. One thing he can rely upon if he strikes a productive well, and that is, that he is drawing upon a stored product which is not now

being formed in the rock from which it is drawn, and that, therefore, he must eventually exhaust the stock of oil from the immediate vicinity of his bore.

SURFACE INDICATIONS OF OIL.—Scarcely a day passes but that I am in receipt of a letter asking me to come to some point in Indiana and locate a well which will produce oil; or stating that bubbles of gas are continually escaping from some pond, spring or stream; or that a scum of oil occurs upon the surface of some body of water. The writers of these letters evidently believe that I possess a knowledge of the surface which will indicate where paying wells can be located, or that such bubbles or scum are certain indications of the presence of gas or oil in paying quantities. If they possess either or both of these suppositions they are woefully mistaken, for in Indiana *there are absolutely no surface indications which denote the presence of either gas or oil in paying quantities in the underlying rocks.* The conditions are such that no man on earth can, with certainty, locate in advance a productive well in any portion of the Indiana field. Gas and oil are found in commercial quantities in the State only at depths ranging from 500 to 1,600 feet below the surface.* Between the formations containing the gas and oil, namely, the Trenton and Corniferous limestones and the Huron sandstone, there are always one or more close-grained shales 50 to 300 feet in thickness. These shales are wholly impervious to both gas and oil; i. e., no particle of either of these fluids can find its way through them. In fact, such a shale is an absolute necessity to the presence of a commercial body of either gas or oil, else both of these would have long since found their way upward into the atmosphere. The bubbles of gas, noted as escaping from water, are, in almost every instance, marsh gas, which is formed by decaying organic matter at the bottom of the water, or in some deposit of carbonaceous material near by. The oil has exuded in minute quantities from some shale, clay, limestone or sandstone, as all such rocks contain some oil. But a drop or two is necessary to form many square feet of film or scum over the surface of a spring or pool. In many instances the supposed oil on the surface of a spring is not oil, but a brownish yellow precipitate of iron oxide.

*The Jasper County field is an exception to this, a heavy form of oil being there found in the Corniferous limestone at 100 to 120 feet below the surface. However, a shale impervious to the oil lies between it and the surface.

Again, the oil producing rocks in Indiana follow no definite direction, as in some other States. There is no northwest-southeast, or northeast-southwest axis or trend which the intelligent operator can follow and sink a productive bore 99 times out of a hundred. His operations in Indiana have always an element of chance connected with them. If he keeps well within the bounds of productive territory his chances of failure are much fewer than if wildcatting on the outside of such limits. But on the best area of known productive territory an occasional bore will come in dry.

Oil Smellers and Oil Finders.—The man with the "hazel rod," the "magnetic finder," and other forms of instruments which can locate oil a thousand feet below the surface is still in existence —still invades our State and catches suckers by the score. He is usually a fair guesser who knows enough to keep inside the limits of known producing territory. There, by chance, six wells out of ten which he locates come in as fair producers and from them he gains a prestige which enables him to land more of the innocent and unwary.

One of these so-called oil wizards has been operating extensively in Indiana during the winter of 1903-'04. He is fathered by a Chicago firm which advertises stock for sale and promises to guarantee the finding of oil to all who will invest. The inventor and handler of the instrument sent out by the company says that it is electro-magnetic in character, and that no one can successfully operate it but himself. According to his belief, all oil flows in streams which are continuous from one State to another and also from one geological formation to another. With this instrument he claims that he can locate these "oil streams" wherever he goes, whether on railway train, on horseback, or afoot. Thirty-five or more of such streams enter Indiana, mostly from the northwest, etc., etc.

It is strange that in an enlightened age like the present such claims and opinions should find credence, and that a company making such pretenses should be able to sell its stock, yet many believe, a number invest, but how many ever have or ever will realize one penny on the investment? There is one instrument and but one that can be used in locating oil in Indiana and that is the *drill.* All others are and ever will be humbugs; and all men who claim to be able to locate oil in commercial quantities by hazel

rods, instruments or what not, are either harmless innocents or fakirs of high degree. The man sent out by the Chicago company above mentioned evidently believes in his instrument and can be classed with the "innocents;" but the company back of him, which guarantees to find oil and pay its investors a handsome profit, is evidently composed of men who take advantage of his innocence to fleece the unwary.

FAKE OIL COMPANIES.—During the year 1903 most of the fake oil companies which came into existence with the discovery of oil at Beaumont, Texas, went to the wall. They reached the acme of their growth and income in 1902 and during the next year gradually dwindled and died. Not one out of a hundred ever paid back a small percentage of the amount invested. The highway robber who takes the money of his victim at the point of a gun is an honest man in comparison with some of these barefaced scoundrels who fleeced victims of high and low degree with the glittering advertising sheets and stock certificates of their mushroom oil companies. In Indiana alone hundreds of thousands of dollars went into the coffers of these fake companies which had their headquarters in Chicago, in Cleveland, and even in Indianapolis. Adams & Sarber, of Cleveland, were at the head of several of these fake companies. This firm failed in June, 1903, with liabilities of $309,792. Their books showed that the income from the stock sold in October, 1902, was $149,709; in November, $156,424; December, $83,601; January, $113,322; February, $113,131; and March, $85,931, or a total for the six months of $702,118, all taken from the pockets of the gullible, and much of it doubtless representing the savings of years.

A large amount of Indiana capital went into the hands of promoters who claimed to operate at Beaumont, Texas. This is lost, even to a penny, as the conditions there existing were at no time such that operations could be carried on with profit, even had honest men been at the head of the company. The Oil Investor's Journal, in speaking of these conditions, says: "Sometimes the failure to obtain revenue from properties has been the result of bad management, sometimes the extraordinary conditions that have arisen on Spindle Top from time to time have prevented the realization of profits, but at the bottom of the whole matter is the unheard of price which most of the companies paid for their prop-

erty. Such figures as those obtained for Spindle Top acreage—and fractional acreage—up to a few months ago, could only prevail where there was some inducement beyond the producing and selling of oil. This inducement was the demand for property for promotion purposes. The promoters felt the pulse of the investing public and with trained faculties for perceiving the heart's desire of this same public, discovered that *what the people wanted was Beaumont oil stock.*

"Without previous experience they went into the field, bought their little piece of proven land, let a contract for a 'guaranteed gusher' and went to work selling stock.

"The 'oil business' on a thirty-second or a sixty-fourth of an acre, even in the Beaumont field with its marvelous production per well, was a speculative experiment, with the odds very heavily against the speculator. The promoter seldom took any chances, but allowed the purchasers of the stock to enjoy the excitement of taking all the risks.

"Those who bought freely of the stocks of these thirty-second-of-an-acre companies are now realizing the difficulties of conducting a successful oil business on a piece of land about the size of the small front yard which goes with a six-room dwelling in a crowded city. It was possible, when the wells first quit gushing, to operate these wells on small lots by compressed air or steam-heads. Compressed air is about played out at Beaumont and steam-heads are giving way to walking-beams, and now the little fellows find they havn't room on the property for a walking-beam outfit."

A number of fake companies were organized to operate in the Jasper County and other Indiana fields and some of them are yet in existence. Their available assets consist of little more than a superb allowance of gall; leases on a few hundred acres of supposed oil territory and a hundred or two dollars invested in prospectuses and stock certificates. All persons are warned against investing any money in any company having stock for sale which claims to operate in Jasper County or vicinity. All holdings of importance in that field, which are yielding any oil of consequence, are owned by the Federal Oil and Asphaltum Company, of London, England, which is a responsible company, but which has no stock on the market. A few other companies whose responsibility is unquestioned are also operating there on a small scale, but they

have no stock for sale. The whole Jasper County field, at the present rate of production, will not yield in 20 years, what a single one of the fake companies offers to produce in one year. Better it would be for the person who has money to invest, to buy grass seed and scatter it abroad for the sparrows, than to invest in the stock of these or other similar companies. The assurance of some kind of returns from the investment would be infinitely greater.

I would go farther, and say do not invest money in the stock of any oil company unless you are well acquainted with the promoters and know them to be honest men who are experienced oil operators. However, if the speculative tendency is too strong to be withstood, either go into the field personally, or send some one in whom you have implicit confidence and investigate the holdings of the company whose stock you are thinking of buying. By so doing you will lessen the profits, as well as the number of such fake companies as we have mentioned. The oil business is a big enough gamble within itself—that is, the risks of losing in the legitimate companies are great enough—without taking a thousand-to-one shot in the stock certificates of those get-rich-quick concerns whose members do not know a walking-beam from a derrick. In investing in oil stock, or anything else, it never pays to "buy a pig in a poke."

SHALLOW BORES IN CENTRAL-SOUTHERN AND WESTERN INDIANA.—Investigations carried on during recent years in the central-southern and western portions of Indiana and records of many bores which have been sunk in those regions, have led me to believe that the majority of the drill holes sunk therein in search of gas and oil failed to reach Trenton limestone, the rock formation which produces the most of the gas and oil in this State. This failure to sink the bores deep enough was due to several causes, chief among which is the great difference in the strata overlying the Trenton limestone in those portions of the State from those overlying the same formation in the main gas and oil-producing areas. In the latter areas the Niagara limestone of the upper Silurian age and the Hudson River limestones and the Utica shale of the Lower Silurian, are the only formations to be pierced by the drill between the drift or surface and the oil and gas-bearing Trenton. In the central-southern and western portions, especially the latter, a number of formations which are wholly absent in the

main gas and oil field, intervene between the surface and the top of the Niagara limestone. The drillers employed during the gas and oil excitement of 1887 to 1895 to sink the bores in these regions were, for the most part, from the gas fields. Their knowledge of geology was small, and in many instances, after passing through a shale which resembled the Utica, and which they doubtless thought was that formation, they called the underlying rock "Trenton limestone," and soon abandoned the bore as barren. The shales which they had pierced may have been any one of a half-dozen carboniferous shales, or, what is more likely, the black Genesee shale, no one of which occurs in the main gas field.

Again, strong flowing veins of salt water were struck in a number of the bores, and the local companies, whose members were paying for the drilling, became alarmed at the extra cost necessary to case off such water, and often abandoned the bore before reaching Trenton. In a number of instances in the southwestern counties, the Corniferous limestones and Huron sandstones which in places, as Loogootee, Birdseye, Terre Haute, etc., are oil and gas bearing, were not even reached, though they lie 900 to 1,400 feet above the Trenton. Wherever a bore was thus abandoned without reaching Trenton, all the money spent was wholly wasted, there being neither negative nor positive results. Moreover, much territory was condemned as non-productive without being given a fair test.

The foregoing statements are not made because I believe that gas or oil in paying quantities will eventually be found in the Trenton limestone of southern and western Indiana, for I have no reasons for such a belief. Neither have I reasons for believing the contrary. If the earlier bores had of a certainty reached Trenton and proven barren, then negative evidence would have been available. The one fact which I do wish to impress upon the citizens of the regions mentioned is that much of their territory has not been properly tested. Another and more important reason for the statement is to induce companies who sink future bores to see to it that nothing stops the drilling before Trenton limestone is reached, or, rather, before that formation has been pierced at least 100 feet. Beyond that depth there is little possibility of finding either gas or oil. A contracting driller of experience can easily and without great expense case off any salt water which may give

him trouble. An accurate record of the thickness of each formation passed through, together with a small vial of the drillings of each, will aid much in determining the horizon which the drill is piercing at any depth, and such record and samples should always be kept.

In contracting for the drilling of oil wells to the Trenton limestone in all parts of Indiana aside from the main field, a written contract should always be made with the driller to sink the bore a certain number of feet, with the privilege of stopping before the distance designated, if so desired, or of going beyond it at a certain stipulated price per foot. The contract should never be worded "to drill to Trenton rock" or "100 feet into Trenton rock," as a dispute is very likely to arise as to that formation. Inside the main field the different formations are well known, and the experienced driller knows within a few feet the distance at which the Trenton will be found. Outside that field, he is apt to be confused, especially if he has to pass through formations not represented in the main field, which he will have to do if the drilling is being done any distance to the south or west. If it is not possible for the parties who desire the drilling done to determine approximately the distance to Trenton limestone, information regarding that point can be obtained in this office. The distance to be drilled should always include 100 feet into the Trenton, as either gas or oil is likely to be found up to that depth. Bores in untested territory which are to be sunk 1,500 or more feet in depth should begin with holes at least 12 inches in diameter, so as to allow the insertion of several sizes of casing if necessity requires. Oftentimes in such bores a stream of water is struck unexpectedly, or a cave of shale or other soft rock occurs, making a new casing necessary. If the hole has been started too small, it often happens that no additional casing can be inserted. It then has to be abandoned or else reamed down, the latter being a tedious and expensive process. By beginning with a large opening there is often much saving of both time and expense.

## THE MAIN TRENTON ROCK OIL FIELD OF INDIANA.

The area of Indiana at present producing Trenton rock petroleum in commercial quantities occupies a portion of nine counties northeast of the center of the State, viz.: Adams, Wells, Hunt-

ington, Grant, Blackford, Jay, Madison, Delaware and Randolph. As shown on the accompanying map, it may be said to comprise about 1,350 square miles, being included within an oblong strip of territory 52 miles long by about 26 miles wide, extending from the Ohio-Indiana State line. westward to the western limits of Liberty township, Grant County, and from Warren, Huntington County, south to Summitville, Madison County. This territory comprises all or a part of each of the following civil townships: Monroe, Blue Creek, Jefferson, Wabash and Hartford, Adams County; Nottingham, Chester, Jackson, Liberty and Harrison, Wells County; Salamonie, Jefferson and Wayne, Huntington County; Van Buren, Washington, Franklin, Center, Monroe, Mills, Jefferson, Fairmount and Liberty, Grant County; Washington, Harrison and Licking, Blackford County; Penn, Jackson, Bear Creek, Wabash, Knox, Miami and Wayne, Jay County; Monroe, Randolph County; Washington, Center and Liberty, Delaware County; Van Buren, Boone and Monroe, Madison County. Of these, Monroe Township, Randolph County, and Center and Liberty townships, Delaware County, lie some distance outside the main field, but it is probable that in a year or two they will be connected with it by the finding of productive territory in the intervening area. Aside from this main field, Trenton rock oil is produced in limited commercial quantities in small areas in Allen, Wabash, Miami, Hancock and Marion counties.

The surface of the main area now yielding Trenton rock oil in Indiana was originally one great plain, with only occasional small undulations to break its monotony. This plain has been eroded in many places by the streams, which in the past have been much larger than at present. Wherever bluffs or hills are found they are but the results of such erosion. But few outcrops of rock occur within the oil field, and they are found only along the streams, where the water has eroded deep channels through the drift and boulder clay, everywhere covering the oil territory to a depth of from 50 to 250 feet. These outcrops belong to the Niagara group of the Upper Silurian Period.

The formations passed through by the drill in all parts of the field before the Trenton limestone is reached are, therefore, as follows: Drift, Niagara limestone, Hudson River limestone, Utica shale. In the eastern half of the field an average section, show-

ing the thickness of each formation passed through would be about as follows:

| | | |
|---|---|---|
| 1. | Drift | 125 feet |
| 2. | Nigara limestone | 150 feet |
| 3. | Hudson River limestone | 425 feet |
| 4. | Utica shale | 300 feet |

In the western portion of the field the average bore shows:

| | | |
|---|---|---|
| 1. | Drift | 175 feet |
| 2. | Niagara limestone | 325 feet |
| 3. | Hudson River limestone | 310 feet |
| 4. | Utica shale | 200 feet |

Throughout the Indiana field an eight or ten-inch drive pipe is forced down through the drift to the Niagara limestone. The fresh water usually found in the Niagara is cased off by an iron tube 5⅝ or 6¼ inches in diameter, which reaches from the surface to the soft blue Hudson River limestone underlying the Niagara. This second limestone and the Utica shale beneath it contain no water. The Trenton is everywhere overlain with the soft, dark colored Utica shale which forms an impervious cover through which neither gas nor oil can escape. From the bottom of this shale the drill passes at once into the hard crust of the Trenton limestone. Two "pay streaks," or porous layers, are usually found in the Trenton, and it is only in them that oil occurs. The first or upper one is usually 15 to 25 feet below the top of the Trenton; the other is 15 to 25 feet below the bottom of the first. While the Trenton rock in Indiana varies in known thickness from 470 to 586 feet, the porous portions containing oil are usually found only in its upper fourth. It has for the

Fig. 2. *Eastern.*

Fig. 3. *Western.*

[redacted]

bou

most part been found useless to drill into the Trenton more than 100 feet, since of the 20,000 and more bores which have been put down in the State but few have found oil or gas below that depth. Within the past year several bores have been sunk in Delaware County which have developed a pay streak at 260 to 300 feet below the top of Trenton. It may be possible that in limited areas such deep bores will prove productive, but this can only be ascertained by future drilling.

In the well records given on subsequent pages the length of the drive pipe represents the thickness of the drift. By subtracting the number of feet of drive pipe from the number of feet of casing the thickness of the Niagara limestone may be ascertained. The distance from the bottom of the casing to the top of Trenton represents the combined thicknesses of Hudson River limestones and shales and Utica shale. The driller calls both of these formations "shale," usually distinguishing them by the terms "blue" and "brown," or "black." The average operator and driller pays little attention to the names of the rock formations passed through, but can tell to an inch how much iron has been used in the bore. The records as given are practically the only ones kept in the field.

THE OIL MAP.—The accompanying map of the main Indiana oil field is the third issued by this Department in recent years. The first, showing the exact area tested up to January 1, 1897, was issued in the 1896 (21st) Report of this Department. The field then embraced but 400 square miles. This map, enlarged and modified so as to show the field as it was on January 1, 1901, was published in the 1900 (25th) Report. The area had then increased to 900 square miles. The third and present map brings the field up to January 1, 1904, and embodies an area of 1,350 square miles, not including a large portion of Madison, Delaware and Randolph counties, which were added to embrace the Parker-Selma pools. Comprised within this 1,350 square miles are many sections which are as yet non-productive, not having been fully tested, owing to the high gas pressure which still exists. Over much of this undrilled territory oil will eventually be found, and the seeming gaps now shown on the map will be obliterated.

During the year 1903 quite an area of producing territory was added to the field. This addition was not due to any notable strike, but to gradual development along the margins of known productive

territory, notably in Washington and Fairmount townships, Grant County; in Bear Creek and Wabash townships, Jay County, and in Blue Creek and Monroe townships, Adams County.

## Adams County

lies adjacent to the Ohio State Line and south of Allen, east of Wells and north of Jay counties. It is 24 miles in length from north to south, and 14 miles in breadth, comprising therefore an area of 336 square miles. The surface is comparatively level, but is well drained by the St. Mary's and its tributaries in the northern half, and the Wabash and its tributaries in the south. Three railways pass through the county—the G. R. & I., from north to south; the T., St. L. & W. (Clover Leaf), and the Chicago & Erie, from east to west—the three having a common junction point at Decatur, the county seat. The population of the county in 1900 was 22,232, as against 20,181 in 1890.

The elevations in feet above tide of the principal railway stations in the county are as follows: Berne, 849; Ceylon, 849; Curryville, 842; Decatur, 800; Geneva, 840; Monmouth, 788; Monroe, 822; Peterson, 817; Pleasant Mills, 799; Preble, 813.

Only the southern third of Adams County has as yet produced petroleum in commercial quantities. The townships of Hartford and Wabash, in the southwestern corner of the county, possess the oldest and best wells; while Jefferson, Blue Creek and Monroe have, in recent years, yielded quite a number of producers. During the year 1903, 317 bores were sunk for oil in the county, as against 291 in 1902. Of these, 30, or 9.4 per cent., were dry. The decrease in dry holes for the year was five, and the percentage of decrease, 2.6. The average initial output of the 287 productive wells was 15.1 barrels, as against 23 barrels in 1902.

*Hartford Township.*—The southern two-thirds of this township has in the past proven quite productive of oil. No territory of importance has been added to the producing area since the former map was issued. Test bores on the Shephard and Cusac leases, south half of section 16, sunk in 1903, came in as very light producers. The recent wells in sections 24 and 28 are to be classed as only fair, most of them coming in at 5 to 20 barrels each. The most successful operations in the township during the year were

on the J. A. Watson farm in section 34, where four wells, out of ten drilled, came in with an iniital output of more than 100 barrels each.

*Wabash Township*—Quite an area of territory, marked as untested on the former map, has become productive during recent years. The southwest quarter of section 7 has a few fair wells to its credit, while the southeast quarter of 12, the west half of 13 and the east half of 14 have each a number of light producers.

The south half of 20 has yielded some good wells and the west half of 22 some light ones. The territory in section 30, just west of Geneva, formerly producing only salt water, is now fairly productive. The west half of section 32 now has a number of good wells within its limits, several of which came in with an output of between 60 and 125 barrels. The west halves of 33 and 35 are lightly productive, the remainder of the township being as formerly shown. The lob, or "deep drive," passes from northeast to southwest diagonally across Wabash township, and has, up to the present, prevented drilling in a number of sections which will doubtless produce much oil in the future.

*Jefferson Township.*—This township comprises but 24 square miles of congressional township (25 N., 15 E.), the two eastern tiers of sections of the congressional township, being a part of Mercer County, Ohio. The first producing wells in the township were opened up in sections 19, 20, 29, 31 and 32, in 1900. Since then a number of fair to good wells have been drilled in other parts of the township, and its entire area will in time doubtless become productive.

In 1903 two good wells were completed on the Johnson lease in section 4, and lighter ones on the Miller and Hunzicker farms. A dry hole was finished on the Hill lease in section 9; and a test, but little better, on the Bedout farm, south half of 10. The south half of 15 yielded one or two fair wells, but those in the southeast quarter of 16 came in light. Two dry holes were drilled on the north half of 20, but the southeast quarter of that section has a number of fair producers. Several 5 to 30-barrel wells, completed in the north half of section 21, on the Vérney, Beeler and Young leases; the top of Trenton being found at 1,065 feet. The north half of 22 yielded one dry hole and three or four fair producers, while tests on the Foster and Reynolds leases in section 34 came in

light. The remaining sections of the township are to be classed as shown on the map.

*Blue Creek Township.*—This township lies north of Jefferson, and like it contains but 24 square miles. Of these parts or all of seven are at present yielding oil.

In 1903 a test on the Cummings farm, in section 8, came in dry, while No. 2, on the Oakley farm in 9, started at only five barrels, with a good supply of gas. A test on the Tague lease, in 16, yielded only gas, but some fair wells were finished on the west half of 15. No. 4 on the D. Studebaker lease in section 31 came in dry, though surrounded on all sides by good wells. A dry hole was also drilled on the Pruden lease in section 29.

*Monroe Township (26 N., 14 E.)*—All developments in this township have been made since the former map was issued. While a number of the 36 sections included in its area have been tested, but four are at present producing oil in commercial quantities.

On the south half of section 22 several wells have been completed on the Habegger lease, which started at 5 to 20 barrels. The No. 4 on the lease was a dry hole, while a test on the Schug lease adjoining started at 25 barrels. Three bores have been drilled on the Lehman farm in the southwest quarter of section 23, which started at 25, 10 and 5 barrels respectively. A second dry hole was drilled on the Eley farm in section 27, the first having been drilled in 1897. The Baxter lease in 29 has yielded a number of fair wells, while the Causey lease on the northeast quarter of 36 has furnished an extension westward of the noted pool in 31 Blue Creek township. Six bores sunk on the lease in 1903 all came in as fair producers, one of them starting at 125 barrels.

*St. Mary's Township.*—Two bores sunk on the J. L. Case farm in section 27, this township, came in dry, while another on the Smith lease in 34 yielded a large amount of salt water and about four barrels of oil.

## Wells County

lies south of Allen, west of Adams, north of Jay and Blackford, and east of Huntington and Grant counties. It comprises an area of 367 square miles, 112 of which are included within the known productive oil territory. The surface of the county is level or gently rolling. The average altitude above sea level is about 850

feet. The Wabash River flows diagonally across the county, entering it on the eastern side, a little below the center, and flowing in a northwesterly direction. The Salamonie flows across the southwestern corner in the same direction, and these streams, with their numerous smaller tributaries, furnish an abundance of running water, and, in most townships, an ample system of drainage.

The soils of Wells County are above the average in fertility. Made up of a mixture of ingredients derived mainly from the decaying rocks of the far north, ground fine and thoroughly mixed as they were by the mighty glaciers which brought them to their present resting places, they contain all the necessary constituents for the growth of the cereal crops, and therefore do not require an annual outlay for artificial fertilizers. Corn and wheat yield enormously in the southern and western portions of the county, and the majority of the farmers were in good circumstances long before the drill revealed that another resource which had been stored since the old Silurian days lay far beneath the surface of the soil they tilled.

Two railways—the Toledo, St. Louis & Western (Clover Leaf) and the Ft. Wayne, Cincinnati & Louisville—pass entirely through the county, while the Chicago & Erie touches its northern border. The Muncie, Hartford & Ft. Wayne electric line, paralleling the Ft. W., C. & L. Railway, is in course of construction, and will be finished in 1904, thus adding to the excellent transportation facilities already existing. The population of the county in 1900 was 23,499, as against 21,514 in 1890.

The elevations of the principal railway stations of the county above sea level are as follows: Bluffton, 835; Craigsville, 850; Keystone, 862; Kingsland, 856; Liberty Center, 848; Murray, 853; Poneto, 849; Tocsin, 837; Uniondale, 814.

Wells County contains the oldest oil producing area of the State, and for a number of years ranked first in production of petroleum, but since 1901 has been exceeded by Grant. However, the townships of Nottingham, Chester and Jackson still rank as among the most productive territory in Indiana. As few dry holes are drilled in them as in any other similar area, and a large number of new productive wells are each year added to those already existing. Outside of the townships mentioned but small areas in Liberty and Harrison townships have as yet proven productive, and it is not

likely that much oil will be found in the county north of the present limits shown on the map, though the greater part of Liberty township may become light productive territory.

*Developments in Harrison Township (26 N., 12 E.) in 1903.*—In this township but four bores were sunk during the year. One on the Quick lease in the southwest quarter of section 29, and one each in sections 25 and 28, developed dry holes. The fourth, on the J. E. Ballentine farm, southeast corner of the southwest quarter of 32, was drilled 300 feet into Trenton, and made about two barrels when shot. It was soon abandoned, and at the present writing there is not a producing well in the township.

*Developments in Liberty Township (26 N., 11 E.) in 1903.*—Isolated wells on a number of sections in the vicinity of Liberty Center have come in as light producers since the former map was issued, and some of the sections in this vicinity may do better in the future.

In the northwestern part of the township, section 7 has developed four light wells and several dry holes. The production is on the Thompson lease, in the southwest quarter, and is from a part of the pool opened up just to the west in section 12, Salamonie township, Huntington County. The four wells were yielding 17 barrels a day on November 1, 1903, the last one having been finished in April. A dry hole has been sunk on the southeast corner of the same lease, and another on the Messburg farm on the same section. Two light wells have been finished in section 17, one on the northeast, the other on the southwest quarter; and one or two in the southeast quarter of 18. A 30-barrel producer was completed on the Davis lease, southeast corner of 19, the remainder of the section being untested. The southwest quarter of 21 and the south half of 28 have also yielded light producing wells, the top of Trenton being found at a depth of 1,014 feet in the southeast of 28. Five or six light wells have also been drilled on the southeast quarter of 29. The west half of 30 has become fair territory, 10 or more wells having been completed on it, but the east half has developed only a salt water producer on the southeast quarter. No. 6 bore, on the J. B. Munsey lease, in 31, started off at 85 barrels on December 15, its record being as follows:

| | |
|---|---|
| Drive pipe | 40 feet |
| Casing | 270 feet |
| Top of Trenton | 930 feet |
| Total depth | 1,000 feet |

Other leases on the same section are fair average producers. Section 32 may still be classed as fair territory, but the only wells so far drilled in 33 are light.

*Developments in Nottingham Township (25 N., 12 E., and a part of 25 N., 13 E.) in 1903.*—This township still maintains its record as a producer, and but few changes are necessary in the former map, where most of the productive territory was classed as good. A dry hole has been sunk on the northwest quarter of section 2, and several fair wells have come in on the Stout lease in the southwest quarter of 3. The producing portions of 4 are light; the bores on the northeast and southwest quarters coming in dry. The west half of 5 is not developed, while the wells on the east half are all light producers, as are also those on the developed portions of 6 and 7. Section 8 remains good territory, and the northwest quarter of 9 may now be called the same, the southeast quarter being lighter. The north half of 10 has been recently drilled with fair results, but 11 and 12 are unproductive. In sections 7 and 8, to the east, the only drilling has resulted in a dry hole or two on the southeast of 7 and a good showing on the C. Bierie in the southwest of 8. Just below these sections a dry hole has been sunk on the northwest of 17, and another on the southwest of 18, the south half of 17 having been wrongly marked as productive on the former map. Section 13 is also nonproductive. The northeast quarter of 14 is undrilled. The Trenton is found low and yielding salt water only on the Kirkwood lease, while bores on the south half of the section have been either dry or water producers. All of 15 except the southeast quarter is fair territory. Section 20, southeast of Domestic, has not held up, the new wells coming in light. The salt water wells, formerly marked on the northeast of 19, caused the abandonment of that quarter section for a time, but it was afterward taken up and the wells drilled deeper, when they came in as good producers. The northwest quarter of the section does not rank as high as the rest. The remainder of the sections in the township remain as marked on the former map. As a proof that the old territory still promises

much to the operator, four wells sunk in 1903, on the Engle lease, in the southeast quarter of 32, started off at more than 100 barrels each.

*Developments in Chester Township (25 N., 11 E.) in 1903.*— This township has been more than holding its own in recent years. The former undrilled area in the northern portion has, for the most part, proven productive; while but a small proportion of the new bores in the older territory came in dry.

Section 1 and the northeast quarter of 2 are as yet undeveloped. The west half of 2 contains some light wells, while the southeast quarter is better. Almost all of 3 has become lightly productive. A test bore on the Speece lease, in the northwest corner, struck a vein of "blue lick" water at 1,027 feet. The northwest quarter of 4 is fair territory, the rest light. Some excellent wells were drilled in on 6 and 7 during the year. One on the Shadle lease, southwest quarter of 7, is said to have made 200 barrels the first day, 400 the second and 190 the third. The west half of 9 and the northwest quarter of 10, marked as undrilled on the former map, have become fairly productive, as has also the greater part of 11 and 12, and the west half of 16. The remainder of the township may be classed practically as on the former map.

*Developments in Jackson Township (25 N., 10 E.) in 1903.*— This township ranks next to Nottingham in its output of oil. But few of the older wells have been abandoned, and all of the undrilled area of the former map has come in as fairly productive. Many of the sections there marked as light or fair, are now classed as fair or good.

On the Huffman lease, south half of section 1, much trouble has been experienced with fresh water, which flooded a number of the wells and caused their abandonment. This mishap was due to some poor wells, whose casing had been pulled, not being properly plugged. Section 5 has increased its rating to fair, while all wells on 6 belong to the same class. One on the Allen lease, southwest quarter of 7, started at 200 barrels, and the whole section is up to the average. The northwest quarter of 8 has only a dry hole to its credit, but the remainder of the section is fair territory; as is also the south half of 9. The west half of 18 has come in as light, but the northwest quarter of 19 has some fair wells to its credit. Section 20, marked as light on the former map, has increased its

standing. The wells are lasting, and most of them start in at 20 to 40 barrels. An average record in the northwest quarter of 20 shows:

| | |
|---|---|
| Drive pipe | 153 feet |
| Casing | 385 feet |
| Top of Trenton | 989 feet |
| Total depth | 1,045 feet |

The first pay is struck at about 1,012 feet, and there is no water before shooting. Section 22 has also increased its output and become fair to good territory. A 160-barrel well was finished on the northwest corner of 24 during the year. The west half of 25 has been fair territory, while 26 now ranks with 27 and 28 to the west. The northwest quarter of 26, containing 21 wells having, according to the pipe line statements for 14 months, a settled production of 65 barrels, together with some undrilled leases in Randolph County, was sold for $75,000 on October 15, 1903. Some changes for the better have been made in the southeast and northwest quarters of 29 and the northeast of 30. Section 31 has been drilled over in recent years with fair results. A bore on the Palmer lease, east half of the northwest quarter, was finished in October, with an initial output of 125 barrels, its record being as follows:

| | |
|---|---|
| Drive pipe | 130 feet |
| Casing | 340 feet |
| Top of Trenton | 985 feet |
| Total depth | 1,045 feet |

The first pay, struck at 1,015, was 18 feet thick. The northeast quarter of 32, formerly bearing only salt water, has recently developed a number of fair wells; while the remaining sections of the township, for the most part, rank high as shown on the former map.

## Huntington County.

comprises an area of 385 square miles, lying west of the counties of Allen and Wells and north of Wells and Grant. The general surface is similar to that of the counties already noted—a level plain, unmarked by any prominent hills or elevated points, the average elevation being about 780 feet above the level of the

sea. The Southern third of the county is drained by the Salamonie River, the central and northern thirds by the Wabash River and its tributaries.

The soil of the county is mostly of glacial origin, varying much in constituents and quality. In most places it is underlain by a stiff, tenaceous clay which retains the surface water and necessitates artificial drainage. Where properly drained it yields large crops of the cereals and grasses. The alluvial soils of the extensive areas of bottom lands along the Wabash and Salamonie Rivers are above the average in fertility, and their crops aid largely in giving Huntington the rank which it holds among the better agricultural counties of northern Indiana.

As in the other counties comprising the oil area of Indiana, the only outcrops of rock are those of the Niagara formation. In the vicinity of Huntington, the county seat, large quantities of lime are burned from this rock, and the quality of the product has given it a reputation second to none in the State.

Two railways, the Chicago & Erie, and the Wabash, cross the county, the former from the northwest to southeast, and the latter from northeast to southwest, while the T., St. L. & W. (Clover Leaf) cuts across the southeastern corner. The Fort Wayne and Southwestern Traction Line parallels the Wabash Railway across the county. The population of the county in 1900 was 28,901, as against 27,644 in 1890.

The elevation in feet above tide of some of the principal railway stations in the county is as follows: Buckeye, 858; Huntington, 741; Markle, 814; Warren, 831.

The area of Huntington County producing oil in commercial quantities is practically limited to the southern halves of Salamonie, Jefferson and Wayne townships, along the southern border of the county. Some of the sections in this area rank high as producers, the average initial production and length of life of the wells equalling any similar area in the petroleum field of the State. It is not probable that the area of productive territory in the county will ever be found to extend any distance north of the townships mentioned, though it may, in time, cover the greater portion of their northern halves.

*Developments in Salamonie Township (26 N., 10 E.) in 1903.*—Operations in this township have been confined to sections 12,

13, 19, 20 and 25 to 36, inclusive, though isolated bores in other sections have produced a showing of oil. On the southeast quarter of 12 two dry holes and two wells which started at 15 and 35 barrels have been drilled, while the only bore on the northeast quarter was dry. The top of Trenton in the last mentioned bore was found at 1,027 feet, while an average record of the bores on the southeast quarter showed:

| | |
|---|---|
| Drive pipe | 58 feet |
| Casing | 385 feet |
| Top of Trenton | 1,007 feet |
| Total depth | 1,087 feet |

The only drilling in section 13 was on the McElhaney lease, northeast quarter, where a 30-barrel well was completed in March, and a lighter one later in the year.

The field opened up in section 19, just west of Warren, in 1900, has not held its own, the new bores having a decreased initial output. The southwest quarter of 20 has on it a few light wells, but the remainder of the section has been condemned by several dry holes. Sections 25 and 26 remain as shown on the former map, while all of 27 and 28 may be classed as lightly productive. The south half of 29 is undrilled, while the north half has developed only salt water and dry holes. The northeast quarter of 30 has some fair wells, but a number of dry holes have been drilled on the other portions of the section. All of 31 has become fair territory, some high-grade producers having been finished on the north half during the year. The southeast of 32 contains nine fair wells, but bores on the remainder of the section have mostly come in dry. Section 33 contains a number of light wells, except on the northeast quarter, which is untested. One light producer has been finished on the northeast quarter of 34 since the former map was issued; the remainder of the section and 35 and 36 remaining as before classified.

*Developments in Jefferson Township (26 N., 9 E.) in 1903.*—This is the best productive township in Huntington County. The wells mostly come in as fair to good producers, and hold up for a long time. The greater portion of the north half of the township is still operated for gas by the Huntington Light and Fuel Company.

One or two bores on the northeast of section 16 have made a good showing of oil, but are not operated. A dry hole has been drilled on the southwest corner of the section. In 17 a bore on the northwest quarter developed only salt water, while 18 is undrilled. Section 19 has developed a number of light wells, the southwest quarter averaging better than the rest. The northeast quarter of 20 is fair territory, the remainder of the section light.

The Pike Oil Company controls several hundred acres of leases in this region, including the northeast of 20 and the northwest of 21. On the Weaver farm, in the latter quarter section, two fair pumping wells were drilled several years ago, and in 1903 they and 160 acres of leases were bought by the Pike Company for $4,000. Three bores have since been sunk by the company on the Anderson farm, in the northeast of 20. A record of No. 2, which started at 120 barrels, is as follows:

| | |
|---|---|
| Drive pipe | 267 feet |
| Casing | 478 feet |
| Top of Trenton | 985 feet |
| Total depth | 1,040 feet |

The first oil was found at 26 feet in Trenton, and a second pay, 11 feet thick, at 35 feet in. A new bore on the Weaver farm in the northwest of 21 resulted in a big salt water well which yielded, with the water, about 15 barrels of oil per day. The southwest of 21 is covered by virgin forest and is unleased, while the east half of the section, as well as 22, 23, 24 and the north halves of 25, 26 and 27 are unproductive. A dry hole has been bored on the Griffith lease in the southwest of 23, and two of the same kind on the Taylor lease in the southwest of 24. The south halves of 25, 26 and 27 have yielded a number of fine wells. A 200-barrel producer was finished in October on the Holman lease in the northeast quarter of 28, which was making 20 barrels when a month old. The northwest quarter is undrilled, while the south half contains a number of fair wells. All of 29 has developed into fair territory, there being nearly 40 producers on the section. The northeast quarter of 30 is unleased. The south half contains a number of fair wells, while on the northwest quarter there is one light well which has never been pumped. An average bore on the Sparks farm, southwest quarter, showed the following record:

| | |
|---|---|
| Drive pipe | 199 feet |
| Casing | 489 feet |
| Top of Trenton | 1,001 feet |
| Gas pay | 1,012 feet |
| First oil pay | 1,025 feet |
| Second oil pay | 1,045 feet |
| Salt water | 1,059 feet |
| Total depth | 1,064 feet |

The east half of section 31 contains 25 oil wells, whose output is above the average. The northwest quarter is undrilled, while the southwest quarter has a number of fair producers. Section 32 has developed into good producing territory. The Troy Oil Company controls the whole section, and on November 1st had 68 producing wells thereon. The oldest of these had been producing four years, and the net production was about four barrels each on the date mentioned. A record of an average bore on the section shows:

| | |
|---|---|
| Drive pipe | 200 feet |
| Casing | 450 feet |
| Top of Trenton | 1,004 feet |
| Total depth | 1,059 feet |

Gas is usually found at 15 to 24 feet in the Trenton before the oil is struck. The former is just about sufficient in quantity to operate the field.

Section 33 is probably the best in the township. On December 1st there were 48 producing wells on its area, with an average production of 7 barrels each. In this section the average record shows:

| | |
|---|---|
| Drive pipe | 250 feet |
| Casing | 450 feet |
| Top of Trenton | 925 feet |
| Total depth | 1,025 feet |

The north halves of 34 and 35 have become fair territory, as has also all of 36.

*Development in Wayne Township (E. ⅔ of 26 N., 8 E.) in 1903.*—The greater part of this township is fair gas territory. Most of the productive oil sections are distant from railway facilities, and hence the operation is light for at least five months of the year. Being on the border of the field, many of the new wells partake

of the "wildcat" variety, and the percentage of failures is greater than inside known productive limits. But eight sections in the southeast corner of the township have as yet proven anyway productive, though a few bores with a fair showing have come in in other localities.

A well on the A. E. Billiter farm, near Mt. Etna, on the southeast quarter of section 1, was completed in 1902, and produced at first a heavy flow of gas and a good showing of oil. In August, 1903, it was put to pumping and made 15 barrels the first day. This well is farther north and northwest than any other in the main Indiana field. It is on the edge of a "deep drive," 340 feet of drive pipe being necessary. Dry holes have been drilled on the northeast quarter of 9 and the corresponding quarter of 10, while 11 and 12 have produced much gas and a showing of oil in some bores. Three light producers have been finished on the Cramer lease, northeast quarter of 15. A bore on the Wilson lease, southwest quarter of 16, came in as a dry hole, with the following record:

| | |
|---|---|
| Drive pipe | 108 feet |
| Casing | 525 feet |
| Top of Trenton | 991 feet |
| Light gas pay | 1,006 feet |
| Salt water | 1,041 feet |
| Total depth | 1,101 feet |

On the Parrott lease, northeast quarter of 23, two bores were producing about 15 barrels of oil in November, the record of No. 2 being:

| | |
|---|---|
| Drive pipe | 331 feet |
| Casing | 525 feet |
| Top of Trenton | 993 feet |
| Gas and oil pay | 1,007 feet |
| Second oil pay | 1,029 feet |
| Total depth | 1,053 feet |

In No. 1, 600 feet east, the drive was but 208 feet. The most of the section is light productive territory, the southwest quarter being undrilled. All of 24 and 25 may be classed as light productive territory, the Searles farm in 24 showing up better than the rest. The Bond farm, northeast quarter of 26 has some fair producers to its credit, but the remainder of the section is as yet

mainly gas producing, as are also sections 27 and 28. On the Hawkins lease in the southeast corner of 33 a 10-barrel well was finished in September, and another of similar output is located on the southwest of 34. The northeast quarter of 35 has developed several fair producers. No. 3, on the Price farm, had the following record:

| | |
|---|---|
| Drive pipe | 229 feet |
| Casing | 500 feet |
| Top of Trenton | 1,009 feet |
| Gas pay | 1,020 feet |
| Salt water | 1,030 feet |
| First oil pay | 1,035 feet |
| Total depth | 1,099 feet |

When completed it pumped nothing but salt water the first day. The second day it made 35 barrels of oil; the third, 37 barrels; the fourth, 40 barrels, and the fifth, 60 barrels. The remainder of section 35 contains a number of light wells, while all of 36 has become fair productive territory.

## Grant County,

in which the most westward extension of the Indiana oil field is located, lies west of the counties of Wells and Blackford, and south of Huntington and Wabash counties. It comprises an area of 416 square miles, the surface of which is, for the most part, level or slightly undulating, though in the vicinity of the Mississinewa River many hills, due to erosion, and from 50 to 100 feet above the level of the river bed, are found.

The Mississinewa enters the county near its southeastern corner, and, flowing in a northwesterly direction, leaves it on the northern border, six miles east of the northwestern corner. In the early history of the county it was navigable for flatboats, which were loaded at Marion and transported, via the Wabash and Ohio rivers, to New Orleans. It and its tributaries drain the greater part of the county; but the western tier of townships is drained by Pipe and Grassy creeks, and the northeastern corner by Black Creek, a tributary of the Salamonie River.

The soils of the county are mostly of drift origin, and for the most part are fertile, though in some localities a lack of necessary drainage has rendered their tillage unprofitable.

The transportation facilities of the county are excellent, the T., St. L. & W. (Clover Leaf), the Michigan Division of the Big Four, the P., C., C. & St. L. and the C., C. & L. railways passing entirely through it, and having a common junction point at Marion, the county seat. Besides these, the C., I. & E. crosses its southwestern fourth, while the Union Traction Company's lines operate between Marion, Anderson and Indianapolis. The population of the county in 1900 was 54,693, as against 31,493 in 1890, while that of Marion was 17,337, as against 8,769. This notable increase was due almost wholly, either directly or indirectly, to the gas and petroleum developments brought about in the county during the decade in question.

The elevations in feet above tide of the principal railway stations in the county are as follows: Fairmount, 880; Fox, 817; Herbst, 851; Jonesboro, 848; Landessville, 864; Marion, 811—814; Miers, 823; Roseburg, 845; Sims, 857; Swayzee, 859; Sweetsers, 844; Upland, 939; Van Buren, 840.

Within recent years, Grant County has come to be the banner petroleum producing county of the State. At the same time the city of Marion has forged to the front as the principal oil center. In 1903 the county yielded more than one-third of all the petroleum produced in Indiana; while the number of new bores sunk was more than twice as great as in any other county. By the close of the year, the townships of Van Buren, Washington and Center had been pretty thoroughly tested. Over most of their area, however, there is room for many new wells, which, in the near future, will undoubtedly be sunk on leases already partially developed. In this way the output of these townships will be kept up, and possibly increased, for a number of years. The greater parts of Mill, Monroe, Fairmount and Jefferson townships will also develop into good oil territory as soon as the prevailing gas pressure is reduced. Monroe and Jefferson townships at present afford as good promise for future production as any within the State. Franklin township is on the down grade and its future output will be light, as will also that of the greater part of Liberty township.

*Developments in Van Buren Township (25 N., 9 E.) in 1903.*—This township, in the northeastern corner of Grant County, comprises one of the oldest and best known oil producing districts of

the State. The first oil well in Grant County was drilled in the outskirts of the town of Van Buren in 1890. From that time up to the present the drill has been kept almost constantly going in Van Buren township, until its area has been pretty thoroughly gone over. The results have been above the average, the township ranking with Nottingham and Jackson, of Wells County, as a reliable producer. The new developments of the year 1903 were mainly in the two southern tiers of sections, most of which were shown as undrilled on the former map, though many bores were sunk on active leases in all parts of the township. The condition of the roads in winter in the south half of this township and in most of Monroe is deplorable, and greatly lessens the development for several months.

The southwest quarter of section 7 has developed into good territory. On the Sanderman lease of 80 acres are 18 producing wells, the last of which was completed in November with an initial output of 150 barrels. A record of its bore was:

| | |
|---|---|
| Drive pipe | 160 feet |
| Casing | 400 feet |
| Top of Trenton | 927 feet |
| Total depth | 1,027 feet |

The 18 wells were producing 70 barrels a day on January 1st, 1904.

The south half of section 8, marked as untested on the former map, has become good territory. On the E. Korporal farm the No. 9 bore, completed in December, started at 150 barrels, and was making 45 barrels at the end of two weeks.

The northwest quarter of section 18, unmarked on the former map, has developed into fair territory, while the east half of section 20 has produced a number of good wells. The whole of section 21 has become fair territory, as has also the southeast quarter of section 24. Sections 25, 26 and 27 are uniformly light, the wells coming in from 5 to 20 barrels each. The east half of 28 and the northwest and southeast quarters of 29 are better, and may be classed as fair, as may also all of section 30, the south half of the latter section being as yet undrilled.

In the lower tier of sections, that portion of 31 which has been tested is light. The northwest quarter of 32 is fair, the remainder light. Much trouble has been experienced with deep drives in the

southeast quarter of the section. The whole of sections 33 and 34 may be classed as fair territory. One of the best wells finished in section 34 in 1903 was drilled in on the M. Dillman farm, starting at about 110 barrels. The deep drive covers part of the southeast quarter of the section and, as elsewhere, renders the drilling difficult. The north half of 35 is light, the south half fair, the R. J. Reed lease of 20 acres in the southwest quarter, being above the average. The northwest quarter of 36 is light, the remainder, as far as tested, being salt water or gas territory. The other sections of the township are mainly classed as shown on the former map, there having been but little change. The wells on the northern two-thirds of the township have come in with a larger initial production than those on the southern third, and, for the most part, have held up remarkably well. Many bores will have to be sunk in the township before all the territory therein is developed as it should be.

*Developments in Washington Township (25 N., 9 E.) in 1903.* —The year 1903 proved that this township is destined to take high rank as an oil producing center. Enough drilling had previously been done to remove it from the "wild cat" area, and as the season advanced the greater portion of the township as far west as the Huntington pike was pretty thoroughly tested. West of that thoroughfare the drills have, on account of high gas pressure, revealed but little of importance. The results of the season's work in the township were equal to the expectations. While no phenomenal strikes were made, most of the wells were above the average in initial output.

Taking up the area in detail, we find that section 1 may be classed as fair, except the northeast quarter, which is light. All of 2 has been proven fair, the southwest quarter showing up better than the rest. Not much drilling has, as yet, been done on the southeast quarter. Section 3, as far as drilled, is light except the west half of the southwest quarter, which is better. The only bore sunk on the B. H. King lease, north half of the northwest quarter, resulted in a dry hole.

A fair average lease in this territory, which is operated carefully on a moderate capital, is that of the "Poor Rut Oil Co.," J. R. Bennett, Superintendent, on the E. J. Hunt farm of 160 acres, southwest quarter of section 2. This farm, up to 1902,

was considered gas territory, and was so marked on the former maps. The first bore was finished for oil on June 1, 1902. Up to October 1, 1903, nine wells had been completed on the east half of the quarter section, and three on the southwest quarter. They are located 600 feet apart and the twelve are operated by one power. Gas is used for fuel in both pumping and drilling, enough being yielded by the wells on the lease for this purpose. All the wells started at about 20 barrels each, but soon settled to an average of 4 barrels which they were doing in October. On the northeast quarter of the quarter section the drift runs about 260 feet in thickness, necessitating that amount of drive pipe. On the southeast quarter of the lease it increases to nearly 400 feet, while on the southwest quarter it is but 250 feet. An average well on the lease shows the following record:

| | |
|---|---|
| **Drive pipe** | **300 feet** |
| **Casing** | **500 feet** |
| **Top of Trenton** | **980 feet** |
| **Total depth** | **1,055 feet** |

Two pay streaks are found, the upper being 30 to 35 feet and the lower and most productive 55 to 63 feet in Trenton. Each pay is about 10 feet in thickness. Between the two, at a depth of about 45 feet in, a screw, in most of the bores, develops salt water which rises about 300 feet in the well. This is easily pumped down, a two inch pipe serving to carry all of it from the twelve wells. The company, up to October 1, 1903, had about $30,000 invested in the lease, and was averaging $1,000 a month income above the one-seventh royalty and cost of operation.

On the E. E. Hewett lease, west half of the southwest quarter of section 3, one mile west of the Hunt farm, a record of bore No 1 was as follows:

| | |
|---|---|
| **Drive pipe** | **199 feet** |
| **Casing** | **504 feet** |
| **Top of Trenton** | **1,004 feet** |
| **Gas struck at** | **1,014 feet** |
| **First oil pay** | **1,019-1,040 feet** |
| **Salt water** | **1,040-1,045 feet** |
| **Second oil pay** | **1,055-1,079 feet** |
| **Total depth** | **1,079 feet** |

The well was a fair producer, as were several others on the same farm.

The east half of section 4 has developed a number of light wells, but west and immediately south of this, the gas pressure is, as yet, too strong to try to operate for oil, so that no drilling has been done in sections 5 to 10 inclusive, nor on the west half of 11. The east half of 11 and all of twelve are fair territory, the H. M. Creviston farm, northeast quarter of 11, and northwest quarter of 12 having yielded a number of wells above the average in initial production. The No. 7, finished July 28, had the following record:

| | |
|---|---|
| Drive pipe | 250 feet |
| Casing | 455 feet |
| Top of Trenton | 1,014 feet |
| First pay | 1,026 feet |
| Salt water | 1,073 feet |
| Total depth | 1,077 feet |

After shooting with 160 quarts, the well started in at 60 barrels.

All of section 13, just northwest of Landessville, and comprising part of the town lot development of that place, may be classed as good territory. On the Elizabeth Cory lease, west half of the northwest quarter, ten wells had been drilled up to October 1st. An average record of these was as follows:

| | |
|---|---|
| Drive pipe | 104 feet |
| Casing | 460 feet |
| Top of Trenton | 1,001 feet |
| Total depth | 1,079 feet |

In a number of the wells but one pay streak was found. Most of them came in with an initial production of 35 to 50 barrels. The wells sunk on section 14 have, up to the present, proven light, while those on 15 are fair producers. The only producing well on 16 is on the L. W. Smith farm, south half of the northwest quarter, where the Marion Gas Co. drilled a well for gas, but found the gas-bearing rock barren. Concluding to drill the well deeper they went 65 feet into Trenton rock and struck oil, the pay streak being about 20 feet thick. The well was then shot with 200 quarts, and a great flow of gas was the result. The well, on January 1, 1904, was making about five barrels of oil while pumping against a heavy gas pressure. It is considered that it has opened up some new territory, as there is not a well nearer

than two miles, and very little water to contend with. The record of the bore was as follows:

| | |
|---|---|
| Drive pipe | 220 feet |
| Casing | 470 feet |
| Top of Trenton | 930 feet |
| Total depth | 1,000 feet |

Section 17 is undrilled. On the west half of the southeast quarter of section 18, near the north border of the H. Cretsinger lease, two light producers have been finished. The record of No. 1 was as follows:

| | |
|---|---|
| Drive pipe | 221 feet |
| Casing | 450 feet |
| Top of Trenton | 970 feet |
| Total depth | 1,032 feet |

The remainder of 18 and all of 19 are undrilled. The only developments on 20 are on the W. Bocock farm, west half of the northeast quarter, where a 20-barrel well was finished October 1st, the bore having the following record:

| | |
|---|---|
| Drive pipe | 210 feet |
| Casing | 450 feet |
| Top of Trenton | 978 feet |
| Total depth | 1,023 feet |

On the G. & M. Bocock farm, southwest quarter of section 21, a bore drilled for oil in June came in as a 1,000,000 foot gas well. The southeast quarter of the section is also gas producing, while the northwest quarter is undrilled. On the south part of the E. W. Creviston farm, in the northeast quarter are several fair producing oil wells. A portion of section 22 has proven fairly productive, especially the northeast quarter, where No. 4, on the C. Sears farm, came in as a 100 barrel producer in September. The record of its bore is as follows:

| | |
|---|---|
| Drive pipe | 318 feet |
| Casing | 455 feet |
| Top of Trenton | 1,018 feet |
| Total depth | 1,061 feet |

The few wells drilled on the south half of the section showed lighter. Section 23, as far as drilled, is fair territory, while the west half and northeast quarter of 24 are good. The northeast

of 25 has proven fair territory; the south half has, as yet, produced only gas. However, deep drives have prevented much drilling, the drift proving 440 or more feet thick. Only dry holes have been found on the southeast of 26. On the B. Smith lease a bore was sunk 325 feet into Trenton, but developed nothing except a little gas at 70 feet in. The southwest quarter of the section is fair territory, as is also the north half of the northeast quarter. The remainder of the section is, as yet, light and gassy. The southeast quarter of 27 is fair, the remainder generally light. On the northeast quarter of 28 a bore was started for oil December 21, 1902, on the E. Conn farm; at 100 feet gravel containing an abundant supply of fresh water was encountered. At 250 feet, a deposit of what the drillers called "red mud" was struck. It is a tough, sticky mud, almost impossible to drive through. The record of the well is as follows:

| | |
|---|---|
| **Drive pipe** | **286 feet** |
| **Casing** | **420 feet** |
| **Top of Trenton** | **987 feet** |
| **Struck gas at** | **1,000 feet** |
| **Total depth** | **1,074 feet** |

The well proved to be a big gas producer, yielding 2,000,000 feet a day for 20 days, with no showing whatever of oil. At the end of that time it was shot with 160 quarts, when a pocket of oil near the bottom of the bore was evidently broken into, as the fluid rose 20 feet above the top of the derrick. The pressure immediately decreased from 180 to 80 pounds. The well made 24 barrels the first day and settled down into a fair producer. It is one of eight on the lease, all of which started with much gas. The northwest quarter of 28 is undrilled. The east half of the southwest quarter has some fair wells, while the southeast quarter has yielded only gas and dry holes. Only the east half of 29 has been drilled. A bore on the Kinney lease on the northeast quarter, came in dry, while the southeast quarter has produced several light wells. Sections 30, 31 and 32 are untested. A dry hole has been drilled on the southwest quarter of 33 and a very light producer on the northwest quarter. The east half is untested. All of section 34 is fair to good territory. On the H. Blinn farm, in the southwest quarter, seven producing wells are in operation, an average record being as follows:

| | |
|---|---|
| Drive pipe | 300 feet |
| Casing | 455 feet |
| Top of Trenton | 998 feet |
| First oil pay | 1,014 feet |
| Second oil pay | 1,035 feet |

A small amount of water is found between the pays, as on the Hunt lease in the north part of the township, already mentioned. The Chas. Brown farm, in the southeast quarter of the section, has furnished eight wells, Nos. 2, 3 and 7 coming in at 60 barrels, or better, each. The gas supply is just about sufficient to furnish fuel for pumping and drilling. The Hawkins lease, on the northeast quarter of 34, has also seven or eight fair producers. The record of No. 7 being as follows:

| | |
|---|---|
| Drive pipe | 173 feet |
| Casing | 440 feet |
| Top of Trenton | 997 feet |
| First oil pay | 1,027 feet |
| Second oil pay | 1,054 feet |
| Total depth | 1,070 feet |

It is to be noted that there is quite a difference in the thickness of drift between the northeast and southwest quarter sections. Section 35 is not so good, the east half being, as yet, mostly gas territory. The Williams farm, on the center of the north half, has produced several light wells and the Howard, in the southwest quarter, a number of fair ones. The south half, as well as the northeast quarter, of 36, has yielded only light wells, while three dry holes have been drilled on the northwest quarter.

*Developments in Monroe Township (24 N., 9 E.) in 1903.*—As an oil producer this township has not as yet been thoroughly tested, mainly for two reasons: 1st. The gas pressure has been too high in most sections. 2d. No railway passes through its area and in winter and spring but little hauling of oil well supplies can be done over the mud roads. However, it is slowly coming to the front, and there is little doubt but that in a few years it will rank with its neighbors on the east and north. Its bounds lie wholly within known productive territory, and such wells as have been sunk have staying qualities. With the going of gas, oil is sure to be found over most of its area in good paying quantities.

Joshua Strange, of Arcana, was the pioneer oil operator in Monroe township. He sank the first well on the northwest quarter of section 15 in 1892. It came in as a dry gas well without a showing of oil. The second well, on the southwest quarter of 10, was finished in October, 1895. It was drilled only 25 feet into Trenton, when the oil rose 600 feet in the bore. The top of Trenton was struck at 987 feet. The third well was on the middle of the north line of the northeast quarter of 15. It was finished in December, 1895, and was at first thought to be a light gas well; but on standing open one night it started to flow oil and flowed for two years before it had to be pumped. The fourth well was on the middle of the west line of the northeast quarter of section 15 and was finished in 1897. It sprayed a little oil but was not pumped until 1900. The fifth well, on the southwest corner of the northeast quarter of 15, came in as a light gasser in December, 1898, but soon began to flow oil over the top of the derrick. By that time Mr. Strange realized that he had a small oil field on his hands and began to operate it in the proper manner. Nos. 4 and 5 were put to pumping in 1900, and No. 3 was flowed by heads. Before any pumping was done, however, he had produced 3,000 barrels by flowing alone. The Ohio Oil Company had meantime put in a pipe-line from Van Buren, five miles to the north, to take care of the product. The surplus gas was piped to Landessville for house consumption. In 1901 Mr. Strange sold his five wells and 440 acres of leases to the National Oil Company for $12,000, retaining a one-eighth royalty on future production. In October, 1903, there were 26 producing wells on the property. During one year, July 1, 1901, to July 1, 1902, the west half of the northeast quarter of 15 produced $24,000 worth of oil at market prices.

Taking up the sections of Monroe in detail, we find that the east half of 1 is fairly productive; the southwest quarter light, while the northwest quarter contains two gas wells and a dry hole. Section 2 is also light. During the year a number of old gas wells were drilled deeper on the northwest quarter, but came in with only a two to five-barrel production. A dry hole has been drilled in the corner of the southwest quarter. The Hodgson lease, which comprises the greater part of the south half, has not yet been tested. The only drilling on section 3 has resulted in three fair

wells on the north half of the northwest quarter, and one light one on the east half of the southwest quarter. The north half of 4, although in the deep drift and requiring 400 or more feet of drive pipe, has produced a number of fair wells, and the southeast quarter some light ones. The southwest quarter is untested, the west half of the southwest quarter being as yet unleased. The greater part of 5 is also untested. The northeast quarter has yielded some fine producers and the north half of the northwest quarter a few light ones. Section 6 has produced three or four fair wells on its west half, but the east half has, as yet, shown only gas. In section 7 two light wells have come in on the north half, the south half and all of 8 being untested. The greater part of 9 is yet producing gas, but some light oil wells have been found on the north half of the northwest quarter, and on the east half of the southeast quarter. Section 10 is also gas territory, though one or two light producing oil wells are on the southwest quarter. The greater part of the north half is as yet unleased. The northwest quarter of 11 is undrilled; the remainder of the section contains a number of light wells in which the gas pressure is still high. The deep drive occurs in the southwest quarter, where the best output has been obtained. All of 12 is as yet light territory, though a number of the bores presage better results when the gas subsides. The record of a bore on the W. L. Thompson farm, just north of Jadden, showed:

| | |
|---|---|
| **Drive pipe** | **425 feet** |
| **Casing** | **430 feet** |
| **Top of Trenton** | **990 feet** |
| **Total depth** | **1,050 feet** |

An old preglacial stream, called by drillers the "Lob," had cut its way down, almost through the Niagara limestone at this point, rendering the deep drive necessary through the drift, which had filled up the channels. The Smith farm, on the southeast quarter of section 13, has yielded some fair wells, one, finished in October, producing 70 barrels the first day. The remainder of the section is undrilled. The northeast and southwest quarters of 14 are undrilled; the southeast quarter contains some light wells and the northwest a number of fair ones. Section 15 has been previously mentioned. It has produced more oil than any other sec-

tion in the township, but this has been mostly found in the northeast quarter. The southwest quarter of the section is yet light producing on account of the gas pressure. Section 16 has not been drilled for oil but furnishes gas from two or three bores.

A light producer and a gas well have been finished on the northeast corner of 17 and a fair producer and a dry hole on the northwest corner. On the Chas. Nelson farm, west half of the southwest quarter of the section, a well was drilled for gas in November. No gas was found at the depth where usually struck, but at 60 feet in Trenton both oil and gas were found, the latter having a pressure of 180 pounds and being too great in quantity to allow the development of the oil. The record of the bore was as follows:

| | |
|---|---|
| Drive pipe | 240 feet |
| Casing | 420 feet |
| Top of Trenton | 930 feet |
| Total depth | 1,010 feet |

In section 18 the only producing wells are on the south half of the northwest quarter, the remainder of the section is yet producing too much gas for development. Drilling for oil on 19 has been confined to the A. Drake lease in the southwest quarter, where a light well or two was finished. In 20 but one light well has been completed, and it is near the south line of the section. Sections 21 and 22 are undrilled for oil. On the Wood farm, northeast quarter of 23, four or five wells were finished during the year, one of which started at 50 barrels and the others at about 10 barrels each. A few light wells have been found on the north half of 24, the south half being untested. In 25 a well on the Kiser farm, northeast quarter, which had yielded gas for two or three years began to show oil in the spring of 1903, and when put to pumping produced about 10 barrels a day. A number of other light producers were finished in the section during the year. Sections 26 to 35 inclusive, where drilled, have, as yet, yielded only gas. In the southeast corner of 36 a number of small producers and one which started at 25 barrels were drilled in during the year on the B. F. Bish farm. Several bores on the C. Brown farm, in the southwest of 34, just north of Upland, were finished in August and showed oil with the gas. The latter had a pressure of 140 pounds. Enough of the bores drilled in

the south half of Monroe township have proven sufficiently productive to warrant the belief that when the gas is exhausted the region will yield oil in good paying quantities.

*Developments in Center Township (Sections 1 to 24 inclusive, 24 N., 8 E.) in 1903.*—That portion of this township east of the city of Marion has been pretty thoroughly tested. The year 1903 saw a large number of bores go down within its bounds, the most of which resulted in fair to good producing wells; thus opening up an area of territory which had hitherto been supposed to be barren. But little drilling has been done in section 1. The Conn lease, northwest quarter, has furnished a dry hole; while the south half has four light producing wells. Section 2 contains 30 or more fair producing wells, those on the southwest quarter being above the average. The record of the bores in the section ran about as follows:

| | |
|---|---|
| Drive pipe | 220 feet |
| Casing | 430 feet |
| Top of Trenton | 930 feet |
| Total depth | 1,010 feet |

The south half of 3 may be classed as fair, while the northeast quarter is good. No. 1, on the Thos. Myers farm was one of the first wells in the Marion field. It was drilled in 1899, and showed some oil but had about 200 pounds gas pressure and was not successfully operated until 1902. Up to the present ten wells have been completed on the lease, all of which are productive. The No. 9, finished in August, 1903, made 200 barrels the first 24 hours.

Section 4 has proven to be a spotted area. The Levi farm, southeast quarter, contains nine fair producing wells, and the owner has received as high as $300 per month royalty from them. The Riley and Bowman leases in the northeast quarter have also several fair producers, but those on the Barley farms are light. Three large salt water wells, which were abandoned after pumping for a year or two, have been drilled on the Coon lease. One of the first wells to show oil in the Grant County field was on the William Brinker farm in the northwest quarter. It was drilled about ten years ago by the Mississinewa Gas Company. In 1900 the company put a separator on the well, had a 25 barrel tank set and ran several tanks of oil. They finally drilled the well in and shot it but it never paid for operating. The southwest

quarter of the section is untested, and west of that no drilling has been done in the northern tier of sections, Nos. 5, 6 and 7 being within the city limits and fair-grounds. The north half of 8 developed a few wells which came in at about 10 barrels. The southwest quarter of 9 is better, but the remainder of that section has shown up light. All of 10 is fair territory with the exception of the southwest quarter. On the east half of this quarter a dry hole was bored, the record being as follows:

| | |
|---|---|
| Drive pipe | 62 feet |
| Casing | 393 feet |
| Top of Trenton | 963 feet |
| Total depth | 1,076 feet |

The greater part of section 11 has proven above the average in productiveness. Two 75-barrel wells were finished on the section during the year. On the T. J. Neal farm in the south half of the section, four wells have been yielding for three years and were still doing 3 barrels each per day in October. The southwest quarter of 12 is undrilled; the remainder of the section has produced only light wells. All of 13 may be classed as fair territory. A 100-barrel producer was finished on the Phillips lease and a better one on the J. R. Nelson farm during the year. The most of section 14 may be classed as light, the majority of the wells coming in at 10 barrels or thereabouts. On the Carriger lease in the northeast quarter of the section a record of No. 4 was as follows:

| | |
|---|---|
| Drive pipe | 169 feet |
| Casing | 449 feet |
| Top of Trenton | 999 feet |
| Total depth | 1,069 feet |

Section 15 is better, the west half ranking high. Nine wells on the Van Vactor farm in the northwest quarter were making 75 barrels daily in October. The Ratcliff lease, just south, had also nine or ten producers the average record of which was:

| | |
|---|---|
| Drive pipe | 75 feet |
| Casing | 400 feet |
| Top of Trenton | 972 feet |
| Total depth | 1,058 feet |

The east half of section 16 developed the first producing well in the Marion field. A number of others have since been drilled but are, for the most part, small producers. Sections 17 and 18, most of which lie within the city limits, have developed a number of light to fair producers during the year. On the Eli Thomas farm, in the southeast corner of 18, a bore finished in December started in at 50 barrels. Several dry holes had previously been drilled within half a mile of it. The record of the bore was as follows:

| | |
|---|---|
| Drive pipe | 190 feet |
| Casing | 410 feet |
| Top of Trenton | 960 feet |
| Total depth | 1,020 feet |

The north half of 19 is light territory, the remainder of the section being either dry or undrilled.

On the grounds of the Soldiers' Home, in the northeast quarter of section 20, the United States government is operating three or four fair producing wells. Six or seven bores have been drilled on the grounds but some of them as yet produce only gas.

The west half of 21 is light to fair territory with some gas. The east half, especially the northeast quarter, is better. On the south half of this quarter the Griffin lease has developed into one of the best in the Marion field. It was first drilled in 1900, when three bores were sunk 50 feet into Trenton. They resulted in light producers. In 1903 these were drilled in 30 feet additional, a second and more productive pay being passed through. Several new bores were also finished, one of which started at 125 barrels. The records of Nos. 1 and 5 were as follows:

| | *No. 1.* | *No. 5.* |
|---|---|---|
| Drive pipe | 160 feet | 220 feet |
| Casing | 440 feet | 400 feet |
| Top of Trenton | 930 feet | 940 feet |
| Total depth | 1.014 feet | 1,020 feet |

The north half of 22 is also high grade territory. The Futrell farm, on the northwest quarter, after being abandoned for both oil and gas, was released and nine wells sunk on it in 1902 and '03. Three of these started at 75 barrels or more each. Most of the wells had but a light showing before being shot, but became

good producers afterward. The south half of the section is not so productive. The only bore on the north half of 23 resulted in a dry hole. The south half is fairly productive. Section 24 may be considered light. As in most other parts of the Grant County field there is yet room for many more bores in Center township and the territory can not be said to have been fully developed until they are sunk.

*Developments in Franklin Township (24 N., 7 E.) in 1903.*—This township lies just west of Marion, and only a small portion of it has been found to be productive. This is mainly in what is known as the West Marion Town Lot development, in sections 11, 12 and 13, where about 90 producing wells were averaging three barrels each in October.

This territory was mainly drilled in 1901 and '02 and while a number of fair wells were finished, it is doubtful whether enough oil was sold to bring back the money invested. The results in both Peru and West Marion have proven that in Indiana, at least, town lot operations are not a shining success. Extra precautions must be taken to prevent damage to adjoining properties, and but few wells can be operated by one power on account of the lots being leased by different companies. A correspondent of the Oil City Derrick correctly sized up the situation in this field in March, last, as follows: "The town lot operators who have been attempting to make the West Marion field represent an elongated pepper-box cover are now having time to think it over, and some of the results of their work are apparent. What was once the liveliest portion of the Grant County field is no longer shining as an example of commemorative industry—in fact, West Marion has gone the way of every other town lot development and those who come out on the good side of a bank account will be fortunate.

"During 1902 there was an air of activity about the West Marion field which indicated that it would long hold a prominent position in Grant County reports. Then it was a common monthly occurrence for the pipe-line company to run 50,000 barrels of oil from the field, and some months it went even higher than this. A survey of the pool during the past week revealed some interesting information. As nearly as can be learned, there are 296 wells in that portion of Franklin township extending southward to Mill and westward as far as operations go. Not two-thirds of these

wells have been operated throughout the winter, and at the present day it may be accurately estimated that the production is not running over 875 barrels per day, less than half the runs when the field was new last summer. Some of the operators in the field might have hired one fireman to tend the boilers on half a dozen leases, so closely were they planted. A majority of the wells are included within the area of one section, one mile square, and are located on lots hardly large enough to accommodate a derrick.

"This is the only portion of the Grant County field which is not at present showing a revival of activity after the cold weather. While many of the leases are being gotten into shape for pumping, there is a noticeable lack of new work—and this is not due entirely to the fact that operators havn't the inclination, but in most cases they can not find unoccupied land."

In section 1 some fair producers have been drilled in on the south half, and some light ones on the northwest quarter since the former map was finished. The nórtheast and the southwest quarters of 2 each have a number of light wells, but the remainder of the northern tier of sections has produced nothing worth noting. Section 11 may be classed as light territory, while the wells drilled in on 12 during the year mostly started at 10 to 30 barrels.

The first well west of Marion was finished on the Sohn lease in 13 in 1901, and the section proved for a time an excellent producer, but most of the bores sunk in 1903 were below the average in initial output and a number of them were dry holes. On the P. Kiley lease, in the southwest quarter, ten wells were averaging a total production of 30 barrels per day in October. An average record of them was as follows:

| | |
|---|---|
| Drive pipe | 80 feet |
| Casing | 375 feet |
| Top of Trenton | 917 feet |
| Total depth | 1,062 feet |

A dry hole or two was completed on the farm during the year. The northeast quarter of 14 is light, the remainder of the section being barren. A bore drilled 300 feet into Trenton on the Wilcutt lease in the southwest quarter of 15 came in dry. The remainder of the township has produced nothing worth mentioning.

*Developments in Mill Township (Sections 25 to 36 of 24 N., 8 E., and 1 to 12 of 23 N., 8 E.) in 1903.*—This township, lying southeast of Marion, contains only 24 square miles. It is composed of parts of two congressional townships and hence the sectional numbers are confusing. Most of the drilling for oil in the township was done in the years 1902 and '03. The bores, while showing much gas, were fewer of them dry than in 1901, and enough oil was found to denote that the greater portion of the area will eventually be light to fair productive territory.

Sections 25 and 26, in the northeast corner are as yet credited as gas producing, though but little drilling has been done on the two sections. On the County Infirmary tract, northwest quarter of 27, is one light oil well and one dry hole, the remainder of the section being untested. Section 28 may be classed as fair, though a few dry holes have been opened on its northern half. An extension of the known field was opened up on the E. Thomas farm, northwest quarter of 29, during the year, when a 40-barrel well was finished, but the Wright farm, just north, has produced three dry holes. The north half of 30 has furnished seven or eight light producers; the southeast quarter one gas well, and the northwest corner a dry hole. Another dry hole was drilled on the northeast corner of 25, Franklin township, the two stopping developments in that direction. Section 31, northwest of Jonesboro, is undrilled. The west half of 32 is light territory but the east half is fairly productive. Five wells on the Metzler lease, finished in 1901, were making four barrels each in October, 1903. Two or three dry holes were finished on the Schrader lease, southeast half of the section, but several fair producers both preceded and followed them.

The most of section 33 lies within the limits of Jonesboro and Gas City. The northwest quarter of the section is fair, but wells drilled between the two towns have come in light or as water producers. East of Gas City, sections 34, 35 and 36 have not been tested except for gas. The A. M. Swain farm, on the southeast quarter of section 1, near the east-central border line of the township, produced some fair wells during the year, in territory before considered good for gas only. An average record of these wells was as follows:

| | |
|---|---|
| Drive pipe | 150 feet |
| Casing | 340 feet |
| Top of Trenton | 935 feet |
| First oil pay | 995 feet |
| Second oil pay | 1,015 feet |
| Total depth | 1,055 feet |

Section 2 is yet considered gas territory. A dry hole was drilled on the southeast quarter of 3, and as yet the section is unproductive. Section 4 is mainly occupied by the town of Jonesboro. Three dry holes were finished on the Johnson and Jay tract in the southwest quarter, and two light producers a little farther west. Section 5 has proven a very spotted area. A number of dry holes, a few wells and some big salt water pumpers were finished on it during the year. Much trouble has been experienced in drilling several of the wells on account of irregularities in the drift. On the A. S. Jones farm in the northwest quarter a record of the average bore is:

| | |
|---|---|
| Drive pipe | 140 feet |
| Casing | 380 feet |
| Top of Trenton | 930 feet |
| Total depth | 1,010 feet |

The east half of 6 is light territory, while the west half yields only gas. Section 7 is as yet untested. A number of bores have been sunk on 8 with varying results. On the E. Russell farm, in the northeast quarter, a 45-barrel well was finished in April, its record being as follows:

| | |
|---|---|
| Drive pipe | 70 feet |
| Casing | 350 feet |
| Top of Trenton | 925 feet |
| Total depth | 1,042 feet |

It was producing 15 barrels in October. The west half of the quarter section is light. The Knight leases on the southwest quarter are fair producers. The southeast quarter is untested. Some dry holes have been finished on the northwest quarter of 9, and a light well or two on the northeast quarter; the south half of the section, as well as all of 10, is undrilled. The northeast quarter of 11 produced two or three fair wells during the year. One on the M. J. Duling lease started at 100 barrels. Others on the same

tract showed much gas and little oil, but the latter will doubtless come when the pressure is lowered. The territory in the region is mainly under lease by large gas companies, which will probably operate it for oil when the lighter fluid is exhausted. A light well or two was finished on the southeast quarter of 11 and a dry hole near the center of the northern half. The Mason farm, in the north half of 12, developed a 30-barrel well during the year, but the gas pressure in other bores sunk in the section was too great to permit of their successful operation.

*Developments in Jefferson Township (23 N., 9 E., and Sections 1-6, of 22 N., 9 E.) in 1903.*—Up to 1903 this township was one of the big gas producing areas of the State. During the year a number of wells, in different parts of the area began to show oil with the gas, and it will be but a year or two until the greater portion, if not all of the township becomes productive oil territory. The gas pressure in all the wells about Upland on January 1, 1904, was about 140 pounds. T. N. Barnsdell, of Marion, has put in a gas line between Marion and Hartford City and is prepared to take care of all the surplus gas, thus giving the oil men a chance to pump their wells. About 40 strings of tools were in the field on the date mentioned between Gas City and the Renner Stock farm in section 6, Licking Township, Blackford County.

In the southwest quarter of section 3, Jefferson township, just southwest of Upland, a 10-barrel well was finished in October. A bore on the Chas. Brown farm in the northwest quarter of the same section came in as a big gas well with a showing of oil. In section 4 two light oil wells and two gas wells have been drilled in on the Safe Glass Co.'s property and a light oil well on the T. Myers farm in the southwest quarter. Section 5 is as yet gas territory. All of 6, except the northeast quarter, is producing oil; four or five wells on the Parks farm, southwest quarter, starting at 30 to 40 barrels each. An old gas well on the S. Johnson farm was drilled deeper and produced 20 barrels the first day. The north half of 7 produced a 90-barrel well on the J. Johnson lease, and some lighter ones on the H. P. Wilson farm, and a well on the J. Johnson farm, northwest quarter of 8, came in with a fair showing. Sections 8 to 16 are as yet gas producing. Bores on the Fergus lease, near the center of section 17 and the Duling farm, northwest quarter of 19, showed the following records:

| | *No. 1 Fergus.* | *No. 4 Duling.* |
|---|---|---|
| Drive pipe | 100 feet | 162 feet |
| Casing | 365 feet | 375 feet |
| Top of Trenton | 886 feet | 925 feet |
| Total depth | 911 feet | 953 feet |

These bores and others in the two sections were gas producing, but their records will show the future oil operators in the region what he has to drill through.

A test well on the E. J. Byall farm, southeast quarter of section 21, finished in August, pumped for a time five barrels of oil against a heavy gas pressure. On the southwest quarter of the same section the Carter lease developed three oil wells and a gas well, the former starting in at 10 to 25 barrels each. Another test on the J. W. Little farm, southeast quarter of 28, was at first thought to be barren, but after drilling 85 feet into Trenton a pay streak 15 feet in thickness was encountered. After shooting with 200 quarts, a gas pressure of 160 pounds developed, but the well produced 60 barrels of oil the first day. It was then shut down on account of the gas. The record of the bore was as follows:

| | |
|---|---|
| Drive pipe | 100 feet |
| Casing | 420 feet |
| Top of Trenton | 920 feet |
| Total depth | 1,020 feet |

In the southeast corner of the township there are two producing wells on the Millhollin farm, northeast quarter of section 1, which are making about five barrels a day. One of them is a big salt water well, pumping through a three inch pipe. A dry hole has also been drilled on the southwest quarter of section 2..

*Developments in Fairmount Township (Sections 13 to 36 of 23 N., 8 E., and 1 to 6 of 22 N., 8 E.) in 1903.*—This township first began to show oil in 1902. Most of its area had been under lease for years to glass companies and to corporations under contract to furnish gas to manufacturers. As the gas supply gradually failed a number of the old wells were drilled deeper and when shot and cleaned began to produce oil in paying quantities. The year 1903 showed a great development in the township and proved that its best paying portion is in the southwest corner, where three or four sections have an output above the average. The territory

has proven rather "spotted" but the fair to good wells have held up their production. The greater part of the township will in all probability produce oil in the near future.

On the Duling lease, northeast quarter of 13, in the northeastern corner of the township, eight bores have been completed, but one of which was productive of oil; the remainder being gas wells. An average record showed:

| | |
|---|---|
| Drive pipe | 175 feet |
| Casing | 414 feet |
| Top of Trenton | 941 feet |

Most of the bores were sunk only 40 feet in on account of the high gas pressure. A number of gas wells are also located on the northeast quarter of 14, but as yet the section shows no oil. Sections 15 to 18 inclusive, have not been drilled for oil. In the southwest quarter of 19 several light wells have been finished, while a dry hole and light producing one are on the southeast quarter. Sections 20 to 23, inclusive, are yielding only gas as yet. The G. E. Duling lease, in the southwest quarter of 24, yielded two light producers which started at about 15 barrels each, but which, after filling a couple of tanks, had to be shut down on account of gas pressure. The record of No. 2 was:

| | |
|---|---|
| Drive pipe | 166 feet |
| Casing | 410 feet |
| Top of Trenton | 944 feet |
| Total depth | 1,045 feet |

On the Leach farm, in the south half of 25, just north of Fowlerton, a well was drilled in 1901, but was not put to pumping until July, 1903, when it produced two tanks in 40 days. Another bore or two on the same farm came in as light producers. Sections 26 to 28, inclusive are, as yet, unproductive of oil. The Fairmount Glass Works finished a light producer and a gas well on its own property in 29. Section 30 has proven a spotted area. The northeast quarter is undrilled, being a part of Fairmount. The south half of the Seal farm on the northwest quarter has produced four or five light wells. The north half of the same farm has several dry holes. The Winslow lease on the southwest quarter is light producing, but the Oakley on the southeast is better. The first well started at 200 barrels, and held up for sev-

eral weeks, but the next three or four yielded only 5 to 12 barrels initial output. On the Galloway lease of 10 acres in the east half of the northeast quarter of 31, three wells were drilled which were producing about 90 barrels a week in October. An average record of them was:

| | |
|---|---|
| Drive pipe | 25 feet |
| Casing | 380 feet |
| Top of Trenton | 930 feet |
| First oil pay | 965 feet |
| Second oil pay | 995 feet |
| Total depth | 1,030 feet |

A number of fair producers were also finished on the Bell and Myers leases, in the west half of the northeast quarter. Bores in the northwest quarter came in light. The southeast quarter produced a dry hole, the southwest a 35-barrel well. Two dry holes were drilled in the southwest quarter of 32 and a gas well on the northeast quarter; while the only bore sunk on 33 was also gas producing. Sections 34, 35 and 36, and section 1 in the southeast corner of the township are as yet classed as gas territory. The south half of section 2 has yielded some fair producing wells, several of which started in at 25 to 40 barrels. The west half of 3 has produced a number of light wells, but the only test on the east half came in dry.

Section 4 has produced more oil than any equal area in the township, but the best wells have been on the south half. On the N. Reif lease of 20 acres in the southwest quarter, three producing wells and two dry holes have been drilled, the average record being:

| | |
|---|---|
| Drive pipe | 98 feet |
| Casing | 380 feet |
| Top of Trenton | 966 feet |
| First oil pay | 994 feet |
| Second oil pay | 1,027 feet |
| Third oil pay | 1,051 feet |
| Total depth | 1,071 feet |

In the dry holes the Trenton was found very fine and hard. The first producer on the lease was an old gas well which began to show oil in January, 1903. It was then drilled deeper and shot, when it yielded seven tanks of oil the first eight days, or an average of 190 barrels per day.

On the W. H. Fellows farm of 40 acres, in the northeast quarter of the southwest quarter of 4, seven wells were finished during the year, all but one of which were productive, starting in at 40 to 125 barrels each. The average bore showed:

| | |
|---|---|
| Drive pipe | 104 feet |
| Casing | 385 feet |
| Top of Trenton | 974 feet |
| First pay | 1,008 feet |
| Second pay | 1,060 feet |
| Total depth | 1,076 feet |

The first well was finished in February and the first oil shipped April 1st. The owner, up to October 1st, had received $1,300 for his royalty of one-sixth, and on that date was averaging $300 a month. No. 1, on the A. J. Leach farm just south, made a tank a day for 20 days, bringing in the owner $4,000 for his one-sixth royalty. No. 2 on the same lease started at 90 barrels, while Nos. 3, 4 and 5 were light. The surplus gas from the pool was being piped to Fairmount, but the back pressure had lowered the oil output of a number of the best prospective wells. The texture of the pay streaks in the pool varied from coarse-grained and porous to fine-grained and close, and the output of each well varied accordingly. On the A. R. Dillon farm in the north half of the section, the first well drilled started at 110 barrels, but in two months was down to a 10-barrel producer.

Section 5 is more spotted. The northeast quarter has developed only dry holes, while the Keever farm in the northwest quarter has a 150-barrel well and one or two light ones to its credit. The first wells in this "pool" were drilled in on the Sluder farm in the west half of the southeast quarter and the farm contains six fair producers. The quarter section is fair territory, some good wells having been drilled on the Underwood leases. The Wood farm near the center of the section has proven light. Section 6 has only one or two light wells and a dry hole to its credit. The latter was drilled on the Sell lease, northwest part of the southeast quarter. On the C. Dean lease, a little farther north are several fair producers, No. 3 of which showed the following record:

| | |
|---|---|
| Drive pipe | 25 feet |
| Casing | 280 feet |
| Top of Trenton | 945 feet |
| Total depth | 1,038 feet |

This bore, when shot, made a tank of oil in eight days.

*Developments in Liberty Township (23 N., 7 E., and Sections 1-6, 22 N., 7 E.) in 1903.*—The greater portion of this township lies along the western edge of productive territory. Only its eastern and southern portions have yet produced oil in commercial quantities. During the year a dry hole was completed on the northeast quarter of section 12, and two light producers on the southeast of 24. The east half of 25 has produced some fair wells. About a dozen were drilled on the M. L. Gaddis lease where the top of Trenton was found at 940 to 950 feet. The Hodson lease, a little northwest, yielded ten wells, nine of them being producers; and the John Seal farm, in the northeast corner of the section, five which were above the average. A bore on the Davis lease in the southeast quarter of 26 resulted only in a small amount of gas. Tests on the Coomler and Rich leases in the northeast quarter of 27 resulted in dry holes, which stopped drilling in that direction. Drilling in 36 has been confined to the northeast quarter. Two light producers and one which started at 60 barrels were completed on the R. Lindley farm in the northeast corner, but two bores on the Cox lease just to the west came in dry. On the Brookshire lease, in the northwest quarter of section 1, in the southeast corner of the township, a bore was drilled for gas in 1901, which partially filled with oil, but yielded neither gas nor water. In November, 1903, it was drilled deeper and started with an output of 25 barrels. Its record was as follows:

| | |
|---|---|
| Drive pipe | 80 feet |
| Casing | 380 feet |
| Top of Trenton | 945 feet |
| Total depth | 1,010 feet |

This well was the farthest southwest of any producing oil in the main Indiana field on January 1, 1904. A gas well on the Call lease, southwest quarter of section 3, has shown signs of oil for some time, but has not been drilled deeper into Trenton in search of it.

*Pleasant Township.*—A test bore, one and a quarter miles northeast of Jalapa, on the D. Steuben farm, northwest quarter of section 10, Pleasant township, Grant County was finished in December, and came in as a light producer. A previous test sunk in the same vicinity in 1901 made a good showing, but was drilled in too deep, and the oil drowned out by salt water.

*Sims Township.*—Two bores have been sunk on the King lease in the northwest quarter of section 12, Sims township, Grant County, in both of which a small quantity of oil was obtained. The pay was found from 88 to 98 feet in Trenton. One of the wells was drilled 141 feet in and struck a large salt water vein. It was pumped three months and then plugged and the lease abandoned. A half tank of oil was obtained from the two wells.

During the year 1903, 1,383 bores were sunk for oil in Grant County, or nearly twice as many as in any other county in the State, Wells County standing second with 735 bores to its credit. Of the 1,383, 94, or 6.8 per cent., were dry. The average initial output of the producing wells was 15.1 barrels as against 18.5 barrels in 1902. The number of bores sunk in the county was 333 more than in 1902, while the number of dry holes was 14, or 3.4 per cent., less than in that year.

## Blackford County

comprises but 167 square miles, embraced in four civil townships. It lies west of Jay, south of Wells, east of Grant and north of Delaware counties. The surface is for the most part level or slightly rolling, the only hills being due to the eroding action of water. The soil, like that of the surrounding counties, is fertile, being of glacial origin and containing, therefore, all the constituents needed by the cereals and grasses. The principal products are the standard cereals, wool and live stock.

The Salamonie River flows diagonally across the northeastern township and with its tributaries drains the northern half of the county; while Lick Creek, a tributary of the Mississinewa, drains the southern half.

The Fort Wayne, Cincinnati & Louisville Railway crosses the county from north to south, and the Pittsburgh, Cincinnati & St. Louis from northwest to southeast, the two crossing at Hart-

ford City, the county seat. The former is paralleled by the Muncie, Hartford City and Fort Wayne Traction line. The population of the county in 1900 was 17,213 as against 10,461 in 1890, the increase being mainly due to the oil and gas developments over its area during the interim.

The elevations in feet above tide of the principal railway stations in the county are as follows: Hartford City, 887-901; Mill Grove, 931; Montpelier, 867; Renner, 907.

About two-thirds of the county is at present producing oil, Washington township, in the northwest quarter, ranking among the best productive territory in the State. Harrison township contains as yet much gas territory. Montpelier, near its northern boundary, being the closest railroad town to the rich fields of the southern part of Wells County has, for a number of years, been one of the principal oil centers of the Indiana field. From it most of the drillers and operators of Wells and Blackford counties draw their supplies, and several Eastern companies which manufacture such supplies have branch houses located in the town.

*Developments in Harrison Township (24 N., 11 E. and Sections 6, 7, 18, 19, 30 and 31, 24 N., 12 E.) in 1903.*—This township comprises 42 square miles, 27 of which are producing oil in commercial quantities. But few changes are necessary in the three northern tiers of sections on the new map. Some abandoned territory in sections 3 and 4 has been released and proven profitable.* Section 6, in the northwest corner, has developed into fair territory in recent years; while the south half of 7 has become good, a second pay streak having been found in the later bores at a depth of 60 to 70 feet in Trenton. The wells in 8 have fallen from good to fair producers. The southeast quarter of section 10 embraces the only unleased area in the northern part of the township, the owner holding out for a larger royalty or bonus than has been offered. A dry hole was drilled in the northwest quarter of 14 and a gas well on the Blount lease just to the east. The northwest quarter of 17 remains undrilled and the southwest quarter contains but a few light wells. The gas pressure is still high in section 18, registering

*See ante p. 93, under "Condemned Territory."

140 pounds on the Hart lease in October. However, some fair wells were finished on the area during the year and the whole section may now be classed as fair. A number of bores have been sunk on 20, but for the most part they have proven very light or dry. The only production is from two light wells on the west half of the northeast quarter. Sections 21 to 24 have not, as yet, proven much better. The north half of 21 has a few light wells and the southwest quarter three dry holes, while two gas wells and a few dry holes are the only results of drilling in 22. In 23 one gas producer and in 24 two dry holes have been sunk in recent years. Sections 25 to 30 are still, for the most part, gas yielders. In 25 there is one small oil producer on the Jackson lease in the southeast corner, and in 26 one of a similar kind in the southwest quarter. Section 31 has developed a number of fair producing wells, though two dry holes have been sunk on the northeast quarter. On the Woodward lease, northwest quarter, one well started at 75 barrels and held up for three months, then gradually dropped to 7 barrels. Its record showed:

| | |
|---|---|
| Drive pipe | 275 feet |
| Casing | 380 feet |
| Top of Trenton | 980 feet |
| Total depth | 1,060 feet |

The first pay was struck at 37 feet and the second at 70 feet in Trenton. The bore is located just on the edge of the "deep drive."

Sections 30 to 36 inclusive are to be classed as dry or salt water territory. The only productive bore in them was finished in January, 1903, on the east half of the southwest quarter of 32. Here, on the Martindale farm, a bore was sunk which developed a large vein of salt water at 50 feet in Trenton. After pumping five days the water began to color up and the well made six tanks of oil in a month and averaged 40 barrels a day for six months. Its record showed:

| | |
|---|---|
| Drive pipe | 135 feet |
| Casing | 315 feet |
| Top of Trenton | 975 feet |
| Total depth | 1,025 feet |

Four dry holes were soon bored just around it and a light gas producer was finished 600 feet to the west.

*Developments in Washington Township (24 N., 10 E.) in 1903.*—This township has a record for bringing in good producers in unexpected localities. A number of them were finished in 1903, and the township produced more oil than all the rest of Blackford County. Developments since the last map was issued have made necessary a number of changes in the then productive sections, while a number then marked as untested have become producers.

The wells in section 1, the south half of 2 and all of 3 and 4 have dropped down from good to only fair average producers, the initial output being much lower than when the area was first opened up. All of section 6 has become fair territory. A bore on the C. Woodward lease in the northwest quarter came in as a 150-barrel producer and made 100 barrels a day for more than a week. All of section 7 has produced fair average wells. Bores sunk in recent years have reduced the standing of 10, the northeast quarter being classed as light, the remainder as fair. The south half of 11 has changed from barren to fair producing territory. Section 12 has fallen back, most recent bores coming in light and reaching a settled production of 2 barrels per day in a week. The older wells in 13 are slowly being abandoned, but the new ones are coming in with a fair average initial output. Section 14 has been pretty thoroughly tested. Some good wells have been finished on the southwest quarter, but the remainder of the section is light and some of the wells yet show a high pressure of gas when first completed. The bores over the greater parts of 15 and 16 come in as fair producers, those on the southeast quarter of each section being lighter. On the Harold farm, southeast of 16, the average record shows:

| | |
|---|---|
| Drive pipe | 200 feet |
| Casing | 365 feet |
| Top of Trenton | 970 feet |
| Total depth | 1,050 feet |

There are six wells on the farm which came in as 5 to 8-barrel producers and dropped to a settled production of 2 barrels per day in a month. Section 17 has become good territory, ranking up with 18 on the west. No. 2 on the J. Futrell farm, west half of the northeast quarter of 18, proved to be the banner oil well

of Blackford County in 1903. It was finished September 25th and started at 275 barrels. The first 32 days that it was pumped it yielded 36 tanks, or a total of 9,000 barrels, for which the company operating it received $11,970. Of this one-sixth, or $1,995, went to the farm owner as royalty. The well, on January 1, 1904, was producing 35 barrels per day. Its bore showed:

| | |
|---|---|
| Drive pipe | 442 feet |
| Casing | 444 feet |
| Top of Trenton | 1,016 feet |
| Total depth | 1,081 feet |

Good paying sand was found from 20 feet in Trenton to the bottom, or a pay streak 45 feet thick, a very unusual occurrence in the history of the Indiana oil industry. Not over 10 barrels of water a day was pumped from the bore. The latter probably struck the center of a small area or pool of very porous Trenton, in which the oil had accumulated. Section 19 remains as before marked. The famous well drilled in on the E. C. Storms lease, west half of the southeast quarter of 19, in 1898, which started at 350 barrels or more and pumped a tank a day for several months, finally went off into salt water and was abandoned for 18 months. In April, 1903, the lease was bought by a new company, the well cleaned out, and put to pumping with a gas engine. It pumped only water until September 15th when the fluid began to color up, and for two months it made 60 barrels of oil a day. The record of its bore was:

| | |
|---|---|
| Drive pipe | 180 feet |
| Casing | 365 feet |
| Top of Trenton | 972 feet |
| Total depth | 1,033 feet |

Other abandoned territory on section 19 has been recently redrilled with good results. (See p. 93.) Section 20 remains light, but 21 has become one of the best areas in the township. A bore on the J. B. Scott lease started in at 300 barrels and was making 180 when it was six days old. Another bore on the same farm came in at 180 barrels. The bores on 22 usually come in as fair producers, 15 to 40 barrels each, but settle down rapidly to 3 to 5 barrels. The northeast quarter of 23, marked as gas territory on the former map, has developed some fair wells,

but the remainder of the section is light, as is also all of 24. The "deep drive" covers most of 25. The southwest quarter has proven barren. The bores on the other quarters come in as light producers with a quantity of gas. Section 26 has developed into fair territory. The "deep drive" covers a part of 27, but most bores sunk through it on this section have proven fair producers. No. 1, on the H. Carrull farm, west half of the northeast quarter, was commenced in April and not finished until July, trouble being experienced in landing the drive-pipe on the Niagara stone. The drive in this bore was 455 feet and no casing was used, as the Niagara was but two feet in thickness. In the deep drives in this vicinity much trouble is experienced with boulders between 200 and 350 feet below the surface, and also in passing through a sticky red clay below the boulders, which reaches to within 15 feet of the limestone. The well started at 60 barrels when completed. The southwest quarter of 27 is lighter, as is also the adjoining southeast of 28; the remainder of the latter section being better. On the Long lease, southwest quarter, are 15 bores, 12 of which are producing oil, two gas, and one dry hole. An average bore shows:

| | |
|---|---|
| **Drive pipe** | **185 feet** |
| **Casing** | **365 feet** |
| **Top of Trenton** | **965 feet** |
| **Total depth** | **1,045 feet** |

All were drilled in 1903, and the 12 producers were averaging five barrels each in October. Sections 29 and 30 are mostly light. Several bores have been abandoned in the northeast quarter of 30. Section 31 and the greater part of 32 are as yet gas territory. The northeast quarter of 32 has developed a dry hole and two light wells. The wells on the north halves of 33, 34 and 35 are fair; those on the south halves are generally light producers. The southeast quarter of 35 and most of 36 have, as yet, produced only gas.

*Developments in Licking Township (23 N., 10 E. and Sections 1-6, 22 N., 10 E.) in 1903.*—This township has, up to the present, proven a great disappointment to oil operators. It was thought, after the Hartford City pool was opened up in 1900, that a wide extension of good productive territory would be ulti-

mately developed south and southwest of that city, but the drill has, so far, failed to locate it. Most of the bores sunk have come in dry, as water wells or as small producers. The pool in the northwest part of the Hartford City limits had the history of all other town-lot pools. While some good wells were opened, their production rapidly dwindled and, as but two or three could be hitched to one power, all but six or eight of them were finally abandoned. While 70 per cent. of the wells in the pool probably paid out, not over five per cent. made a profit. The best lease in the pool was the 40 acres of Widow Downey. On it five bores were sunk, two of which came in dry. From the other three, located on five acres of the lease, $70,000 worth of oil was sold, and the three, when four years old, were still producing 25 barrels a day in November, 1903. Such results, more than anything else, show the gambling feature of the oil industry in Indiana.

Taking up the productive area of Licking township by sections, we find that section 1 is a spotted area. One big salt water well on the north side of the S. Carrell lease made 100 barrels a day for a time, but on the south side of the same farm only gas has been found. All of 2 and three-quarters of 3 are light territory; the northwest quarter of the latter section being better. The east half of four contains a few light producers, but only a few light gas wells have been drilled on the west half and on 5.

The Renner stock farm of 540 acres, comprising the greater part of 6, has recently developed three wells, the average initial output of which was about 15 barrels. A gas well on the Townsend farm, southeast corner of the same section, was recently drilled deeper and shot when it made 10 barrels of oil and a fair supply of gas. No. 2 bore, on the same lease, came in as a 5-barrel producer. A small oil well has been drilled on the Rogers lease, northeast quarter of 7, and some gas wells with a showing of oil on the Smith, in the northwest quarter. Section 8 is unproductive, while 9 has only a few light wells on the northeast quarter. The north half of 10 comprises the Hartford City pool, and may yet be classed as fair. The Johnston Window Glass Company, drilled in a dry hole and a 5-barrel well on its lots in this area in 1903. The northeast quarter of 11 may be classed as light, while 12 and 13 as yet produce only salt water. One or two very light producers have come in on the

northeast quarter of 14, but all bores on 15 have proven barren. The east half of 16 is light productive territory and a small well has recently been finished on the Johnson lease in the northwest quarter of the same section. Several gas wells on the southeast of 17 have sprayed oil from time to time, but as yet there is no producing well on the section. A test well on the Stanley farm, northeast quarter of 18, came in as a 6-barrel producer and two gas wells on the Williams, northwest quarter of 19, contain more or less oil which has not been pumped. Section 20, as yet, has shown no signs of oil, but a gas well on the Chapman farm, northwest quarter of 21, has sprayed it in quantity. On the Swift lease, southwest quarter of 22, are several light wells, and on the Drayer, southeast quarter, a bore drilled for gas came in as a 50-barrel producer. In section 27, just south, two bores were sunk, one of which yielded a small amount of oil while the other was barren. Tests on the Moonan farm in the southeast quarter of the section yielded gas only. The remaining sections of the township are wholly unproductive of oil, though a number of them still produce gas.

*Developments in Jackson Township (23 N., 11 E.) in 1903.*—Although this was counted one of the best gas producing townships in the State, but a few sections in the northwest corner have yielded oil. Where the gas has been exhausted, salt water seems to have taken its place. Therefore the chances of successful drilling for oil over the greater part of its area seem at present very slight.

In section 5 two dry holes have been drilled in the northwest quarter, while a bore sunk 250 feet into Trenton, on the Taylor lease near the center, developed only a little gas. Section 6 has produced a number of light wells. Four on the Hemminger, in the northeast corner, came in with an initial production of 10 barrels and soon dropped to 3 or 4 barrels. On the Hiatt farm, on the northwest quarter, are four big salt water wells, each pumped with a separate power and with a three-inch tubing to carry off the water. The four, in November, were making about 30 barrels per day. An average record shows:

| | |
|---|---|
| Drive pipe | 116 feet |
| Casing | 320 feet |
| Top of Trenton | 965 feet |
| Total depth | 1,023 feet |

The Stroble lease, in the southwest quarter of 6, has developed two dry holes and two light wells. One light producer has been finished on the northeast of 7, the remainder of the section being barren. A test on the Wingate farm on the south half of 10 brought a bountiful supply of salt water at 35 feet in the Trenton; while another on the southwest of 14 came in wholly dry. A bore which showed a large quantity of oil was finished on the Wentz farm, southwest of 17, but it was plugged on account of a too bountiful output of gas. Two gas wells were also sunk on the southwest quarter of 18 during the year. The remainder of the township is either untested or gas territory.

## Jay County

comprises an area of 370 square miles, lying adjacent to the Ohio State line, south of Adams and Wells, north of Randolph and east of Blackford and Delaware counties. The surface of the county is gently rolling or nearly level, and the soil of most portions proves very fertile where properly drained and tilled. The Salamonie River flows through the county from southeast to northwest and drains its western and southern halves. The Wabash River touches its northeastern corner and through its tributaries drains the townships of Wabash, Bear Creek and Jackson.

The G. R. & I. Railway, passing north and south through the center of the county, crosses the L. E. & W. main line, running east and west, at Portland, the county seat. The P., C. & St. L. crosses the southwest corner of the county, passing through the thriving towns of Dunkirk and Redkey, so that the facilities of transportation in all directions are excellent. The population of the county in 1900 was 26,818 as against 23,478 in 1890.

The elevations above sea level of the principal railway stations in the county are as follows: Blaine, 930; Briant, 869; Brice, 924; Como, 949; Dunkirk, 946; Portland, 909; Powers, 991; Redkey, 966.

During the year 1903 Jay County forged rapidly to the front as an oil producer. Quite an area of new territory was opened up in Wabash and Bear Creek townships, while several light

producing wells in Wayne and Noble townships bring a portion of their area within the limits of future prospective territory. But few leases have been abandoned in the county since the former map was issued, and most of these abandoned leases have been released and are being redrilled. During the year 213 bores were sunk in the county as against 94 in 1902, a gain of 127 per cent. Of the 213 bores, 33, or 15.5 per cent., were dry, the percentage showing a decrease of 5.5 from the previous year. The average initial output of the new wells in the county was 13.4 barrels as against 14.1 in 1902.

*Developments in Wabash Township, Sections 3 to 10, 15 to 22 and 27 to 34 (24 N., 15 E.) in 1903.*—This township comprises only 24 square miles, in the northeastern corner of Jay County. The area of producing territory in southern Jefferson township, Adams County, shown on the former map, has been extended southward, and covers parts or all of seven sections in Wabash township. Several fair producing wells have been finished in the north half of section 4 and some lighter ones in the north half of 5. Section 6 and the east half of 7 is fair productive territory, while the west half of 7 has yielded a number of good wells. The average bore in these sections shows:

| | |
|---|---|
| Drive pipe | 40 feet |
| Casing | 290 feet |
| Top of Trenton | 1,025 feet |
| Total depth | 1,115 feet |

A number of light to fair producers have come in on the north half of 8 and one or two on the southwest quarter. A dry hole was bored on the Bricker lease, northwest quarter of section 17, and another on the Miller lease in section 30. The northeast quarter of 18 is light territory, but the west half of the section is better, as is also the northwest quarter of 19. In sections 18 and 19 the drive pipe runs from 80 to 300 feet, the top of Trenton being found at about 1,040 feet.

*Developments in Bear Creek Township (24 N., 14 E.) in 1903.*—Of the 36 square miles embraced in this township, 17 are at present producing oil in commercial quantities. Quite an area of new territory was opened up in the northeast corner of the township during the year.

Section 1 and the north half of 2 embrace some fair productive territory, but the south half of 2 is lighter, tests on the Macklin and Bloom leases in that area coming in dry. A few light wells are yielding on the southeast quarter of 3, the remainder of the section being undrilled. The west half of 4 has some fair wells to its credit, but all new bores recently sunk on section 5 have proven light; while those on 6 are coming in only as fair producers. A bore on the southeast quarter of 6, completed November 6th, yielded quite a quantity of gas instead of oil, the rock pressure starting at 130 pounds, but soon falling to 20 pounds. The record of the bore shows:

| | |
|---|---|
| Drive pipe | 115 feet |
| Casing | 238 feet |
| Top of Trenton | 1,087 feet |
| Total depth | 1,157 feet |

The portion of 8 marked as undrilled on the former map at present contains some light to fair wells, while a test on the Chaney lease on the southeast quarter of 9 started at 5 barrels. The northeast quarter of 10 produced one or two light wells during the year, as did also the northwest of 11. Several fair producers have been finished on the northwest and southeast quarters of section 12. An average bore of these shows:

| | |
|---|---|
| Drive pipe | 40 feet |
| Casing | 260 feet |
| Top of Trenton | 1,034 feet |
| Total depth | 1,107 feet |

The pay streak is struck about 15 feet in Trenton and is usually softer and more porous than in the counties to the west.

The wells on the east half of 13 and the northeast quarter of 24 are light to fair producers. The west half of 16 and the east half of 17 are now producing some oil, though at one time a number of dry holes were drilled on them. A test bore on the Bishop farm, northwest quarter of 20, showed up dry, as did another on the Francks lease in section 26 near West Chester. The remaining sections of the township remain either undrilled or as shown on the former map.

*Developments in Jackson and Penn Townships (24 N., 14 E. and 24 N., 13 E.) in 1903.*—But few changes are necessary

in the old map in these two townships. The north half of Jackson still retains its record as the best productive territory in Jay County, while the southern half remains very spotted. Recent bores in section 6 have proven light. Some of these are on the south half, hitherto undeveloped. Section 7, being in the deep drive, is yet untested. A dry hole was sunk on the Williams, southeast quarter of 8, during the year. The east half of 9 is now fair territory, while the south half of 13 has come in with several good wells. A dry hole was drilled on the northwest quarter of 15; while a test on the Ganey lease, north half of 25, was a 5-barrel producer. A dry hole was also completed among some gas wells in the northeast quarter of 32, but the southeast quarter of that section is now lightly productive, as is also the southwest of 33. A light well has also been finished in the southeast quarter of 36.

The territory in Penn township has, in the past, been distant from railway facilities, and many farms which doubtless contain oil beneath their surface have, for that reason, not been tested. A new railway has just been completed from Camden (Pennville) to Portland, which will doubtless prove a factor in causing more extensive operations in that portion of Jay County.

The lob or "deep drive" runs through both Jackson and Penn townships, and renders drilling very tedious and often expensive. It is not uncommon to use 400 or more feet of drive pipe in a number of the bores sunk in it before striking limestone. As a result, the region of the lob has been avoided, but since the wells hitherto sunk near it have mostly come in as fair to good producers the present high price of oil will doubtless lead operators to take the risk, and a number of the untested sections in Penn township will in the future become productive. But few bores were sunk in the township during the year. Two tests on the Gray farms, west half of 12, proved dry, as did another on the Brown lease, southeast quarter of 14. Old gas territory in the southeast quarter of 27 produced a fair well or two; as did similar territory in the southeast quarter of 30. With the exception of three wells in Pike township, the four townships above mentioned comprise the only area in Jay County at present producing petroleum in commercial quantity. A number of test bores sunk in other portions of the county during the year were

as follows: In Wayne township, sections 5, 6, 10, 21, and 26, had a bore or two sunk on them, all of which made a showing of oil, sufficient to insure more extended operations in the future.

In Noble township a bore sunk on the southwest quarter of section 27 developed a small well. In Pike township, the three wells on the Ware and Lush leases in sections 8 and 9, sunk in 1901, are still producing 4 or 5 barrels; while a test put down on the northeast quarter of section 34 has recently come in as a small producer.

During the latter part of the year four or five fair producing wells were finished near Redkey, on sections 24, 25 and 36, Richland township. Two of these on the W. Barnell lease, southwest quarter of section 24, started at 25 barrels each, their record showing:

| | |
|---|---|
| Drive pipe | 135 feet |
| Casing | 265 feet |
| Top of Trenton | 964 feet |
| Total depth | 1,040 feet |

It is probable that a large portion of this township may become productive in the future, thus serving to connect up the Jay County territory with that now yielding oil in Monroe township, Randolph County.

According to records gathered by Benjamin Fulton, one of the most experienced operators in Jay County, he gives it as his opinion that "There is a ridge of Trenton lying between Redkey and Portland and between Redkey and Camden or Pennville, which seems to be too high for oil. Every well around the edges of this ridge where the Trenton was found as low as 950 feet, showed indications of oil. However, where the Trenton was found at shallower depths, nothing but gas was obtained. This ridge comes within three miles of Portland on the west and southwest, and at Portland Trenton is found at 985 to 990 feet; four miles south of Portland at 1,050 feet, and two and a half miles northwest and two and a half northeast of Portland, at 1,030 to 1,045 feet. In section 27, Noble township, Trenton was found at 1,045 feet. In section 21, Bear Creek township, at 1,040; in section 25, Jackson township, at 1,030; in section 24, Green township, 970 to 980. From this data of depth, I will

go on record that the oil field will extend eventually clear through Wabash, Bear Creek, Noble, Wayne, Pike, Jefferson and Madison townships in Jay County, and connect up with a new field that will open up in Randolph County."

## Madison County

lies south of Grand and west of Delaware and Henry counties. It comprises an area of 460 square miles, the surface of which is level or gently rolling. The drainage is to the southwest by way of White River, which crosses the county from east to west near its center, and has numerous tributaries permeating all portions of its area.

The railway facilities of the county are ample, the Michigan Division of the Big Four passing through it from north to south while the Cleveland Division connects Anderson, the county seat, with Muncie and Indianapolis. The P., C., C. & St. L. crosses the county diagonally from northwest to southeast. The Chicago and Southeastern (old Midland) crosses the county from east to west near its center and the L. E. & W. runs across its northern third. Besides these, the lines of the Union Traction Company run in various directions from Anderson.

The discovery of natural gas over much of its area about 1885 led to a rapid growth in its wealth and population. The towns of Elwood, Alexandria, Summittville and Frankton in the northern half, which had before ranked only as country villages, rapidly assumed the size and prerogatives of cities, while Anderson, the county seat, almost doubled in size. The phenomenal growth of these places in ten years may be seen by the following comparative table of population:

| | *1890.* | *1900.* |
|---|---|---|
| Alexandria | 715 | 7,221 |
| Anderson | 10,741 | 20,178 |
| Elwood | 2,284 | 12,950 |
| Frankton | 520 | 1,464 |
| Madison County | 36,487 | 70,470 |

The elevations in feet above sea level of the principal railway stations in the county are as follows: Alexandria, 855; Anderson, 854-894; Chesterfield, 907; Elwood, 862; Florida, 881; Frankton, 834; Gilman, 901; Orestes, 871; Pendleton, 847; Summittville, 879.

Only the northern third of Madison County has produced petroleum in paying quantities; and that only in limited areas in Boone, Van Buren and Monroe townships. In the first two mentioned the developments were mainly during the year 1903, but about Alexandria, Monroe township, a number of wells have been producing since 1898. These three townships have been large gas producers in the past, and there is little doubt but that they will develop many paying oil wells in the near future. Outside of their area the chances of opening up productive territory in the county seem small.

*Developments in Boone Township (Sections 7 to 36, 2 N., 7 E.) in 1903.*—In this township I could learn of but two bores in which oil had been obtained. One on the Howard lease, northeast quarter of section 9, is said to contain several hundred feet of oil. It was sunk for gas and penetrated the Trenton only 32 feet, the top of that formation being struck at 972 feet. One-half mile west, in the northwest quarter of the same section, a well on the J. Campbell lease has been pumping a small quantity of oil for some months, and in October had filled nearly a tank.

*Developments in Van Buren Township (Sections 7-11, 14-23, 26-35, 22 N., 8 E.) in 1903.*—This township has up to the present produced oil only in the northern tier of sections; 7-11, next to the Grant County line, and in 21, just east of Summittville. In the northeast quarter of section 8, several bores, yielding only gas, were sunk on the Sluder lease in a vain endeavor to extend the Fairmount township, Grant County pool in that direction. The C. S. Wood farm, in the southeast corner of 10 developed one or two light wells, but three bores sunk on the C. M. Leach lease in the northwest quarter found gas alone.

Quite a pool of fair productive territory has been opened up in section 11. The wells mostly came in good for 10 to 30 barrels initial output, though a few of them were better. About 30, scattered over the section, were completed by October. An average record ran about:

| | |
|---|---|
| Drive pipe | 180 feet |
| Casing | 380 feet |
| Top of Trenton | 978 feet |
| Total depth | 1,062 feet |

In section 20, near Summittville, a dry hole was located on the Vardeman lease. In 21, just east of that town, several productive wells and dry holes have been drilled. The Crystal Glass Company owns two of the producers. No. 1 was drilled for gas on a town lot of their property in the northwest quarter of the section in April, 1902. It came in as an oil producer, starting at 120 barrels. At the end of two months it was cleaned, when it made 175 barrels for a few days. The Standard put in a line and piped the oil to Montpelier. The output gradually decreased, and after producing about 8,500 barrels the well ceased to yield. A record of its bore showed:

| | |
|---|---|
| Drive pipe | 140 feet |
| Casing | 400 feet |
| Top of Trenton | 951 feet |
| Total depth | 1,077 feet |

The first pay was found 40 feet, and the second between 70 and 80 feet, in Trenton. The second bore of the same company, half a mile east on the northeast quarter of the section, was finished in October, 1903, and started at 50 barrels, but was down to 3 barrels in two weeks. A bore 1,500 feet northwest of No. 1 was sunk 165 feet in the Trenton but was dry. Another a little farther northwest, on the Cowgill lease, in the southeast quarter of 17, was also dry.

On a town lot just south of the schoolhouse, in the eastern limits of Summittville, a bore sunk for gas in 1902 began to show oil and in the spring of 1903 was drilled deeper and shot. It started at 120 barrels and produced 11 tanks, when it ceased to yield. Its bore showed:

| | |
|---|---|
| Drive pipe | 120 feet |
| Casing | 440 feet |
| Top of Trenton | 940 feet |
| Total depth | 1,042 feet |

A dry hole was drilled 50 yards west and another 300 yards northeast, while a small producer was finished 50 rods east which was making 5 barrels a week in October. This shows the spotted nature of the Trenton in the section. Scattered bores sunk over the remainder of Van Buren township have developed only gas; though most of them have been drilled only a shallow depth into the Trenton.

*Developments in Monroe Township (Portions of 21 N., 8 E. and 21 N., 7 E.) in 1903.*—This is the township in which Alexandria is located, and in the immediate vicinity of that place a number of wells have been producing since 1899. The high gas pressure has interfered greatly with their operation and the drilling of a number of dry holes has not added prestige to the region. As a consequence a large number of the wells first in operation have been abandoned. However, a number of light producers were finished in the township during the year, so that the annual output of the field has been maintained.

In section 10, one bore which yielded 50 barrels, natural flow, the first day, was finished on the Hughes lease, while others on the same farm came in very light, or dry. A dry hole and a small well or two were completed in the northwest quarter on the Baker lease, and a fair well in the northeast quarter on the Markle farm. The latter, when finished in August, started at 50 barrels and was down to 10 barrels by January 1st. One or two bores in the northwest of 13, just west of Alexandria, were dry or very light. On the southwest of section 15, four miles east of Alexandria, a test on the Swindell farm in comparatively new territory came in for 75 barrels. The southeast quarter of 17 produced two fair wells and a dry hole. A test on the Miller lease in the northeast quarter of 22, (21 N., 7 E.) started at 50 barrels, while a second bore is said to have been a little better. Two or three fair wells and a dry hole were also finished on the northeast quarter of 29. Of the 34 bores finished in the township during the year, 14, or 41 per cent., were dry; while the 20 producing wells had an average initial output of but 9 barrels, so that the Alexandria field was not remarkable for its record during the year. The output of the field by months during 1903 was as follows:

PRODUCTION OF THE ALEXANDRIA, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1903.

| | *Barrels.* |
|---|---|
| January | 16,742 |
| February | 17,382 |
| March | 22,903 |
| April | 18,760 |
| May | 22,424 |
| June | 22,717 |
| July | 25,914 |

| | |
|---|---|
| August | 26,345 |
| September | 25,214 |
| October | 26,505 |
| November | 24,310 |
| December | 22,667 |
| Total | 271,883 |

On the William Shafer farm, southwest quarter of section 24, Duck Creek township, three and a half miles east and four miles north of Elwood, The Pittsburgh Plate Glass Company drilled a well in October, 100 feet into Trenton rock. It came in with an initial production of 20 barrels. The well has since been shut down, as the company claims that it did not pay to operate it. On the same farm, 500 feet south, the same company drilled a well 300 feet in the sand. They found gas and a little oil at 65 feet, but nothing from there on, and the well was abandoned. The record of its bore showed:

| | |
|---|---|
| Drive pipe | 36 feet |
| Casing | 228 feet |
| Top of Trenton | 938 feet |
| Total depth | 1,238 feet |

## Delaware County,

comprising an area of 399 square miles, lies east of Madison, north of Henry, south of Grant and Blackford and west of Randolph and Jay counties. Its soil is of drift origin and very diversified, but is, for the most part, noted for its fertility. White River crosses the county from east to west a little south of the center, and together with its tributaries drains the southern two-thirds. The Mississinewa, flowing in a northwesterly direction, crosses the northeastern fourth and, with its tributaries, furnishes ample drainage for the northern third.

The transportation facilities of the county are most excellent. The Cleveland Division of the Big Four; the Lake Erie & Western; the Chicago, Cincinnati & Louisville, and the Ft. Wayne, Cincinnati & Louisville, all intersect at Muncie, the county seat, and from that point diverge in all directions. Besides these, the Chicago, Indiana and Eastern from the northwest and three interurban traction lines, two running west, and one north, have their terminals in Muncie.

The discovery of natural gas over the larger portion of Delaware County and a consequent increase of large and important manufactories, led to a rapid growth in population. The increase from 1890 to 1900 of the three larger towns, as well as of the county, is shown as follows:

| | *1890.* | *1900.* |
|---|---|---|
| Muncie | 11,345 | 20,942 |
| Albany | 571 | 2,116 |
| Eaton | | 1,567 |
| Delaware County | 30,131 | 49,624 |

The elevations in feet above tide of the more important railway stations in the county, are as follows: Albany, 939; Cammack, 931; Daleville, 910; De Soto, 956; Eaton, 910; Gilman, 901; Muncie, 950; Oakville, 1,008; Reeds, 929; Royerton, 928; Selma, 1,005; Shidelers, 911; Yorktown, 924.

While Delaware County is not, as yet, noted for its output of petroleum, it promises much for the future. Washington township, in the northwestern corner, has been producing more or less since the first wells came in near Gaston in 1897. The gas pressure in that part of the county has, however, for the most of the time since, been too high to permit of the lawful securing of the oil. Liberty and Delaware townships east and northeast of Muncie have been the scene of extensive operations for several years, while more recently, that portion of Center township just northeast of the city limits has developed a number of producers. All the area tested in these three townships seems, however, to be very spotted territory, and up to the present the chances of securing a dry hole or a fair producing well are about equal. The field is remarkable in that three or four bores sunk during the year developed a pay streak rich in oil at 240 or more feet in the Trenton. Isolated bores in other sections of the county have from time to time developed a fair showing, and the greater part of the northern half of the county will eventually produce more or less oil. But it is doubtful if the industry in Delaware County ever reaches the magnitude it has assumed in Grant, Wells, Blackford and other counties, to the north and northeast.

*Developments in Washington Township (Sections 7-36, 22 N., 9 E., and 12, 19, 24, 25 and 36, 22 N., 8 E.) in 1903.*—The first producing wells in this township were drilled in on the W.

H. Broyles lease, northeast quarter of section 36 (22 N., 8 E.) in the fall of 1897. They produced large quantities of both gas and oil, and were closed by injunction on March 12, 1898. Four wells, located on adjoining farms to the south were closed at the same time. The three wells on the Broyles lease struck Trenton at 940, 935 and 933 feet respectively. In October, 1900, Howland & Company put down a fourth well, 24 rods north of No. 2, striking Trenton at 937 feet. In order to shut off the gas they used ten-inch drive pipe and six and a quarter inch casing. Inside of the latter, five and five-eighth-inch casing was used clear down to the oil. Two pay streaks yielding gas were found, the first 25 to 45 feet, the second 65 to 80 feet in. The inner casing was sunk to a depth of 1,019 feet, or below the gas "pay." A packer was put in below the gas and one above. Below the gas, 18 feet of oil rock was found, the oil being raised through two-inch tubing without waste of gas. The outfit was quite expensive, but was, for a time, fairly successful, the output of the well being about 40 barrels daily, which flowed by heads. An arrangement was utilized by which enough gas for running the engines was secured from the supply held between the packers. After the well had been pumped a while the oil became partially exhausted for a distance around the foot of the bore and the gas found its way down and up inside of the tubing, the experiment thereby proving a failure. Mr. Broyles received from Howland & Company $2,000 bonus and one-sixth royalty for 82 acres of his farm, and the same amount for a second 80 acres, from the American Window Glass Company, the latter company agreeing to pay also $100 per year for each gas well drilled, from which the gas was piped away for use. Most of the bores since sunk on the lease have proven small gas producers.

The only new bores sunk in the township in 1903, were on the north half of section 12 (22 N., 8 E.), where eight were finished on the Couch and Richards farms. Much trouble was experienced in some of them with both salt water and gas. Seven of the eight came in as producers, the average initial output being 12 barrels. The best of the wells started at 25 barrels, while one bore yielded only gas. This is an eastward extension of the pool in the northeast corner of Van Buren Township, Madison County.

*Developments in Delaware Township (Sections 1 to 25, 21 N., 11 E.) in 1903.*—The first producing oil well sunk in this township was finished in 1901, on the Krohn farm, southwest quarter of section 11, and a mile southwest of the town of Albany. Trenton rock was struck at 925 feet and penetrated 50 feet. The bore yielded 60 barrels of oil and a large amount of salt water the first day it was pumped. Two other bores sunk in 1901 in the same vicinity proved dry.

During the year 1903, 17 bores were finished in the township. Of these nine, or 53 per cent., came in dry. The eight producers had an average initial output of 21 barrels each. Two dry holes were completed on the Brammer lease in the northwest quarter of 18, but a third bore, sunk 306 feet in Trenton, made 85 barrels the first day and was good for 50 barrels when a month old. Its record showed:

| | |
|---|---|
| **Drive pipe** | **28 feet** |
| **Casing** | **294 feet** |
| **Top of Trenton** | **921 feet** |
| **Total depth** | **1,227 feet** |

A dry hole was drilled on the Bartlett farm, in the south half of 2. The north half of 4 has produced several fair wells and the southwest quarter one or two light ones. Of two bores sunk on the Davis farm, northeast quarter of section 6, one, finished in November, started at 12 barrels, and on January 1st was making half as much. Another, 600 feet north, developed salt water, 40 feet in Trenton and did not pay to pump. The average record showed:

| | |
|---|---|
| **Drive pipe** | **44 feet** |
| **Casing** | **337 feet** |
| **Top of Trenton** | **940 feet** |
| **Total depth** | **1,000 feet** |

Test bores on the northeast quarter of 5 also came in light, while others on the Bartlett lease in the southeast of 13 produced only gas. The best strike of the season in the township was on the D. Michael farm, northeast quarter of 15, where a test bore finished on November 3d, started without shooting, at 160 barrels, and for 35 days pumped natural 70 barrels per day. It is said that no oil was struck until the drill had pierced Trenton 240 feet. A record of the bore was as follows:

| | |
|---|---|
| Drive pipe | 40 feet |
| Casing | 370 feet |
| Top of Trenton | 920 feet |
| Total | 1,195 feet |

This big strike in territory hitherto unproductive and at so great depth in Trenton caused much excitement among the oil fraternity, and by January 1st, five other bores were drilling on the same lease, and four on adjoining tracts. One of these, located 800 feet north and east of the Michaels well, on the E. Black lease, southeast quarter of section 10, came in as a 100-barrel producer, its record being as follows:

| | |
|---|---|
| Drive pipe | 27 feet |
| Casing | 310 feet |
| Top of Trenton | 921 feet |
| Oil pay | 270 feet |
| Total depth | 1,232 feet |

Another test on the Peterson farm, southeast quarter of section 18, came in as a 25-barrel producer, while two or three bores on the Dowell lease, southeast of 22, were light or dry. A test on the Williamson farm, in 23, showed only gas, as did another on the Payton farm, in the northwest of 30.

*Developments in Center Township (Sections 1-25, 20 N., 10 E., and 31-36, 21 N., 10 E.) in 1903.*—Operations in this township were wholly on sections 1, 2, 11, 12, 35 and 36, just northeast of Muncie. On this area 13 bores were sunk, 7 of which came in dry, while 6 had a total initial output of 126 barrels, 100 of which was yielded by a single well.

In section 36, northeast corner of the township, one light producer and a dry hole were finished on the McCormick lease, and a light one on the Reed farm just west, while a test on the Sears lease came in dry. What was at first a dry hole, but which after shooting became a million-foot gas well, was finished in the southeast corner of 35, its record being:

| | |
|---|---|
| Drive pipe | 47 feet |
| Casing | 350 feet |
| Top of Trenton | 920 feet |
| Total depth | 1,015 feet |

On the north half of the southwest quarter of section 1 the big well of the district was finished about August 1st. It was on

the E. E. McGalliard farm, where three or four light wells had been previously drilled. It started at 12 barrels an hour and made 1,800 barrels in seven days, but by September 20 was down to 35 barrels a day. A record of its bore showed:

| | |
|---|---|
| Drive pipe | 42 feet |
| Casing | 341 feet |
| Top of Trenton | 969 feet |
| Total depth | 1,011 feet |

Another bore, 600 feet south, was a dry hole, while another the same distance northwest developed a pay streak but four feet thick and came in as a 5-barrel producer. Two others on the Shirey lease, just north, were both dry. This is a good illustration of the spotted character of the territory in this region. In section 2, just to the west, a bore on the Crews lease also came in dry with the following record:

| | |
|---|---|
| Drive pipe | 30 feet |
| Casing | 328 feet |
| Top of Trenton | 907 feet |
| Total depth | 949 feet |

A big salt water vein was tapped at 25 feet in Trenton and the bore was soon after abandoned. Two light producers were finished south of the Crews on the southeast quarter of 2 and a salt water well on the Watt lease, northeast of 12. In the latter salt water was found at 20 feet in Trenton and a stronger vein at 90 feet in. Drilling was continued to 140 feet in, with the hopes of striking an oil pay, but without results. In a bore on the Haney lease, northeast quarter of 11, it is reported that the Utica shale was a reddish brown in color. The Trenton was pierced 417 feet, and it is claimed that a pay streak was struck at 202 feet in, and after shooting there was 100 feet of oil in the bore, but the latter caved and the well was abandoned.

In this Center township area about the only pay is found 18 to 30 feet in Trenton and it runs about 15 feet thick. It is, for the most part, fine and gritty. If no accidents occur, a well can be completed ready for shooting in 12 days, but the majority of them take 15 or more days.

*Developments in Liberty Township (Sections 1-25, 20 N., 11 E., and 31-36, 21 N., 11 E.) in 1903.*—This township furnishes most

of the production in Delaware County. In 1903, 81 bores were sunk within its limits, 28, or 34 per cent. of which were dry. The 53 productive wells had an average initial output of 21 barrels, but the greater part of the total initial production was from six or eight big wells.

Dry holes were sunk on the northeast quarter of section 36 and on the northwest quarter of section 1. A few light wells were finished on the south half of 3, while a test on the southeast quarter of 6 came in barren. The county farm, on the southeast quarter of section 8 has proven one of the best productive areas in the township. The first oil well completed on it was an old gas well which was drilled deeper and shot in 1901. It started in at 35 barrels and additional bores were at once sunk around it. On October 1, 1903, there were 11 producing wells and three dry holes on the farm. The producers were making a total of 70 barrels a day. The cost of operation was $125 per month. The records of a salt water bore and the No. 11 producer, both of which were completed in 1903, show:

| | *Salt water well.* | *No. 11.* |
|---|---|---|
| Drive pipe | 76 feet | 55 feet |
| Casing | 333 feet | 343 feet |
| Top of Trenton | 914 feet | 917 feet |
| Total depth | 969 feet | 975 feet |

Two light producers and a big salt water well have been finished on the northeast quarter of section 8. On the Abergast lease, northeast quarter of 9, an old gas well began to show oil in 1899. It had been sunk but 20 feet in Trenton, but was drilled 50 feet in and shot, when it produced a small amount of oil. As there was then no pipe-line to carry away the oil, the well was abandoned after about 100 barrels had been pumped, most of which was wasted. In 1903 a second bore was sunk 600 feet east, which produced a large amount of salt water and some oil. If it had been shot and put to pumping it might have developed into a fair well. A dry hole was finished on the Hindman lease, southwest quarter of 9, during the year.

The Schrack farm, southwest of 12, furnished one big oil well, two light ones and a gas well in 1903. The big well started at about 180 barrels. An average bore on the lease shows:

| | |
|---|---|
| Drive pipe | 85 feet |
| Casing | 335 feet |
| Top of Trenton | 976 feet |
| Total depth | 1,030 feet |

Test bores on the Jones farm, northwest quarter of 13, and on the Patty lease, southwest quarter of the same section, came in barren. The latter was a big salt water well and its record showed:

| | |
|---|---|
| Drive pipe | 95 feet |
| Casing | 352 feet |
| Top of Trenton | 980 feet |
| Total depth | 1,013 feet |

Section 14 has proven the leading producing area in the township. The L. Winget lease, near the center of the section, had, on October 1st, six wells producing an average of 200 barrels daily. The No. 3, finished July 16, started at 200 barrels and on October 1 was still yielding 75 barrels. A record of Nos. 3 and 4, 300 feet west, follows:

| | *No. 3.* | *No. 4.* |
|---|---|---|
| Drive pipe | 104 feet | 97 feet |
| Casing | 350 feet | 364 feet |
| Top of Trenton | 984 feet | 988 feet |
| Total depth | 1,040 feet | 1,035 feet |

Two pay streaks were encountered, the first 14 feet, the second 27 feet in Trenton. Gas is used for fuel while drilling and gas engines for pumping. The lease averaged a tank a day between July 16 and October 1. On the Winget, Anderson, Black and Dunkin leases, embracing an area of one-half square mile, five companies were operating December 1st. All these leases were developed in 1903, the nearest producing wells previous to that date being one and a quarter miles east. The Anderson farm of 40 acres, just north of the Winget, was sold by the owner for $5,000 early in the season. The buyers, up to October 1st, had sunk on it five producing wells which, on that date, were yielding 65 barrels a day. The Dunkin lease west of the Winget, yielded three or four small producers, as did also the Black lease in the south half of the northwest quarter of 14. A bore completed in the northeast corner of the section was also good for only five barrels. A dry hole was finished on the Sweeny lease, north half of southeast quarter of 15, while the Campbell and

PLATE II.

KITTERMAN WELL, NEAR BIRDSEYE, IND.

WELLS ON THE WINGET LEASE, EAST OF SELMA, IND.

East farms on the west half of 16 had several light wells to their credit. The top of Trenton in this section is found at about 938 feet. An old gas well on the Burt lease north half of 17, was drilled deeper and started at 10 barrels, but two others found salt water only. A test on the Graham lease, northeast of 18, was light, but No. 1 on the Guthrie lease just west, developed a 35-barrel producer, while No. 2 started at 150 barrels. Records of their bores showed:

| | *No. 1.* | *No. 2.* |
|---|---|---|
| Drive pipe | 65 feet | 61 feet |
| Casing | 321 feet | 330 feet |
| Top of Trenton | 886 feet | 890 feet |
| Total depth | 1,172 feet | 1,161 feet |

The principal pay streak of oil in the two wells was found at 42 feet in Trenton.

Just south of Smithfield in the southwest corner of 22, the F. M. Cannaday farm has developed four fair producers, the average record of which shows:

| | |
|---|---|
| Drive pipe | 80 feet |
| Casing | 338 feet |
| Top of Trenton | 940 feet |
| Total depth | 1,017 feet |

Two dry holes have been finished on the southwest quarter of 27, while a light producer was finished on the Williams farm in the northeast quarter. The first well to show oil in Liberty Township was on the Cecil farm in the northeast quarter of 28. A gas well began blowing off oil in 1900 and was drilled 80 feet into Trenton and shot. Before shooting, the oil is said to have stood 300 feet deep in the bore, but it came in as only a 5 barrel producer. Soon after this, a bore sunk for gas on the Z. T. Dunkin lease just to the south, yielded 15 barrels of oil when completed. The third bore in the field was on the F. M. Cannady lease in 22. At 35 feet in Trenton a large salt water vein was tapped but the bore started at 50 barrels. The Cecil lease at present contains three, and the Dunkin lease five or six, fair producers. One of these, sunk in 1902, started in at 135 barrels, and produced the usual excitement of a rich strike in comparatively new territory. It was near the corner of the farm, and four bores sunk within 300 feet in different directions came

in dry. Just west of the Dunkin and Cecil leases, several light producers have been developed on the A. R. Lennon farm, an average record showing:

| | |
|---|---|
| Drive pipe | 124 feet |
| Casing | 340 feet |
| Top of Trenton | 972 feet |
| Total depth | 1,051 feet |

The depth to which the wells are sunk in the Selma field is governed very largely by the appearance of the drillings from the Trenton. Salt water is often found 30 to 40 feet in, and a rather close white sand at about that depth warns the driller of its probable proximity. If there are no signs of water, the drill is often sunk 75 to 100 feet into Trenton. Where the territory is productive, two pay streaks are almost always found, one 15 to 20 feet in, the other 30 to 37 feet. A pipe-line station has been put in by the Indiana Pipe Line Company, just west of Selma, from which the oil from Center and Liberty townships is piped to a larger station at Montpelier, Indiana. The Republic Iron & Steel Company, of Muncie, which is operating a number of the largest producers in the Selma field, has use for all the surplus gas produced from its wells, and so is not bothered as are some of the other oil operators by the gas pressure. When gas at a low pressure is put into a pipe line for factory use it is often forced or held back, and so lessens the output of oil. A pump which will force the gas from a single well into a lead pipe can be had for $75. If used in connection with the oil pump, it will remove the back pressure of gas and so allow the ready production of the oil.

From what has been said about the different parts of the Delaware County field, it will be seen that the oil appears to be in little pockets or pools. No productive area of any size has as yet been found. As one of the leading operators said, "the territory is as spotted as a leopard's back, and the spots are very far apart."

The following table shows the number of barrels of oil piped from the Muncie-Selma-Parker oil field by months for the year 1903:

PRODUCTION OF THE MUNCIE-SELMA-PARKER, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1903.

| | |
|---|---|
| January | 15,108 |
| February | 19,639 |
| March | 25,268 |
| April | 21,714 |
| May | 39,155 |
| June | 56,159 |
| July | 58,474 |
| August | 56,667 |
| September | 55,914 |
| October | 57,597 |
| November | 49,632 |
| December | 54,204 |
| Total | 509,531 |

## Randolph County

comprises an area of 450 square miles lying next to the Ohio State line, and south of Jay, north of Wayne and east of Delaware and Henry counties, Indiana. The surface of the county is generally level or rolling, but the area which it embraces is one of the most elevated in the State, its southern part forming the principal watershed of eastern Indiana. The numerous streams which rise within its bounds flow in every direction. Both Whitewater and White rivers have their sources within the county, the tributaries of the former draining the southern third and those of the latter the central third, while across the northern third flows the Mississinewa, which is also fed by numerous small streams.

The soil of the county is, for the most part, a heavy clay enriched by the vegetable accumulations of ages. The clay, being of drift origin, is composed of the debris of many different formations which contains all the elements necessary for plant food. Wheat, corn and grass are the leading productions; the cereals and live stock furnishing the principal income of the agricultural classes.

The county is supplied with the best of transportation facilities. Two divisions of the Big Four Railway cross it from east to west, one near its center, the other across the southern third. The G. R. & I. bisects it from north to south and the P., C.,

C. & St. L. cuts across its northeastern fourth, while the C., C. & L. touches its southwestern corner. The population of the county in 1900 was 28,653, as against 28,085 in 1890.

The highest land in Indiana is on the middle ridge near Bloomingsport, on the "Summit" between Green's Fork and Martindale Creek, where the elevation on the Peoria Division of the Big Four has been found to be 1,234.4 feet above sea level. Some of the hills south of this point are estimated to be 50 feet higher, so that 1,285 feet is approximately the highest level in the State. The elevations of the principal railway stations in the county are as follows: Carlos, 1,208; Crete, 1,181; Deerfield, 1,004; Farmland, 1,037; Harrisville, 1,101; Johnson, 1,177; Losantville, 1,128; Lynn, 1,162; Modoc, 1,174; Parker, 1,023; Ridgeville, 982; Saratoga, 1,044; Snow Hill, 1,174; Stone, 1,034; Union City, 1,102; Winchester, 1,089; Woods, 1,183.

Monroe township, on the western border of Randolph county, has developed a number of productive oil wells in recent years some of which have had an output equal to any in the State. The territory has, however, proven to be very spotted, the number of dry holes equaling or exceeding those with an output sufficient to pay for pumping. Isolated bores in White River and Stony Creek townships have also developed small producing wells. From present indications the future production will probably be limited to the northeastern third of the county, which comprised the former principal gas yielding area within its bounds.

*Developments in Monroe Township in 1903.*—This civil township comprises a part of four different congressional townships and the numbers of the sections are, therefore, very confusing. It embraces the south halves of sections 29 and 30 and all of 31 and 32 (21 N., 13 E.); sections 5 to 8 and 17 and 18 (20 N., 13 E.); the south halves of sections 25 to 29 and all of 32 to 36 (21 N., 12 E.), and sections 1 to 5 and 8 to 17 (20 N., 12 E.). In the north part of the township a gas well was finished on the Thornburg farm in section 27, while a test on the Wood lease in section 32 came in dry. The Keever lease, south half of 33, has a number of fair producers to its credit; while the Boots farm to the west and the Wood lease to the north each possess several light wells. A bore or two on 34 came in light, while a test on the McGunnigal in 35 developed a dry hole. The south-

east quarter of section 3 has yielded a few fair producers, but tests on other parts of the section were barren. The east half of 4 is first-class territory; the Bennett lease on the southeast quarter having yielded a number of big wells. No. 1, when finished May 22, was apparently dry, but when shot with 400 quarts began to flow and produced 200 barrels the first day and 3,000 barrels the first month. Its record shows:

| | |
|---|---|
| Drive pipe | 99 feet |
| Casing | 337 feet |
| Top of Trenton | 965 feet |
| Total depth | 1,068 feet |

The Trenton is said to be in thin strata or layers and has the color of whitewash on the bailers. By the first of October the well had settled down to 12 barrels per day. No. 2 Bennett at first showed a little gas, but no oil. A shot of 400 quarts caused it to start at 250 barrels; while No. 3 also came in as apparently barren, but yielded 150 barrels after shooting. Nos. 4 and 5 on the same lease were dry.

The west half of 4 has produced only light gas wells or dry holes. Several light wells have been found on the Meeks lease, southeast of 5, and the northeast of 8, but a number of dry holes have been drilled with them, and those sections are considered poor property.

Section 9 is the most noted area in the field. The famous "Cecil gusher," probably the best well drilled in Indiana in 1903, is located in the midst of a number of others on the east half of the southeast quarter. It was No. 10 on the E. E. Cecil lease, finished May 2, 1903, when it started at 420 barrels, and averaged more than 300 barrels a day for four months. The oil was almost wholly free from water, so much so, in fact, that it became necessary at times to run water into the tanks and steam it in order to get rid of the sediment. A two-inch pipe was taxed to its full capacity to take the oil from the pump to the tanks, and on September 23 a three-inch pipe was put in and the well made 20 barrels an hour for several days. The well was pumped on the beam, 40 strokes to the minute, and a stand of 3 tanks was necessary to take care of its production. A record of its bore showed:

| | |
|---|---|
| Drive pipe | 136 feet |
| Casing | 346 feet |
| Top of Trenton | 1,007 feet |
| Total depth | 1,047 feet |

The top of the oil pay was found at 1,025, and a continuous pay streak 22 feet thick was passed through to the bottom. The top of Trenton in this particular lease seems to be very uneven, the drill showing it to be in waves or crowded anticlines. Bore No. 13, on the southeast corner developed the Trenton at 974 feet, while 40 feet east, on the adjoining lease, it was found at 960. In No. 10, the big well, it was found lower than in any other bore, being struck at 1,007 feet. No. 9 well, on the same lease, finished April 4, started at 320 barrels and was making 65 on October 1. On the same date there were 15 wells on the E. E. Cecil farm of 143 acres, and eight on the Z. Cecil lease, just to the west. On the latter lease the first bore, finished in July, 1902, made two tanks in 27 hours, but soon dropped to a 25-barrel producer. The record of No. 3 on this lease was exactly the same as No. 2 on the E. E. Cecil, showing:

| | |
|---|---|
| Drive pipe | 120 feet |
| Casing | 345 feet |
| Top of Trenton | 965 feet |
| Total depth | 1,015 feet |

The 23 wells on the two leases were producing 900 barrels a day on October 1st, and several good ones were drilled later in the year. On the northeast quarter of 9 the wells are fair producers, but those on the west half of the section are light. The southwest quarter of 10, just east of the E. Cecil lease, contains some fair wells, but tests on the remainder of the section are either barren or water wells. A gas well was finished on the Grove farm in 11, and the only producing well in the section, located on the southwest quarter, is light.

A test drilled on the Macy farm, section 12, just north of Farmland, came in dry, as did another on the Mason farm in section 14. The Ezra Cecil lease in 15 developed two producing wells and three dry holes during the year. One of the wells started at 45, the other at 125 barrels. A half dozen wells on the north half of 16 are light producers while one or two other bores in

the section are dry. Two old wells on the Scott lease in 17 and one new one finished in 1903 have an output of 3 to 5 barrels a day.

The above comprises the development in the famous Parker field up to January 1, 1904. It will be seen that four or five sections produce practically all the oil in the township. The results of the drilling during the year showed that 116 bores were sunk in the Parker field. Of these 42, or 36 per cent., were dry. The 74 producers had an average initial output of 45 barrels. Fourteen of the producers in sections 4, 9 and 15 started in at 100 barrels or more each, their total initial output being 2,100 barrels, or 150 barrels each. The other 60 producing wells had an average initial production of 20 barrels each. The field is thus seen to be very spotted and one well tests only a location. Public attention has been called to the big wells, but the dry holes and small producers have been seldom mentioned.

*Developments in Stony Creek Township During the Year 1903.*—This township lies just south of Monroe on the western side of the county. But few bores have, as yet, been sunk within its limits. A test on the McIntire lease, section 19, three-quarters of a mile west of Macksville, started at five barrels, while another on the N. Knobe farm, in section 30, south of Macksville, struck the top of Trenton at 984 feet. This formation was then pierced 99 feet before a pay streak was encountered. This was seven feet thick, and the total depth of the bore 1,084 feet. It came in as a three-barrel producer. A dry hole or two was completed on the Swingley lease south of Windsor, on the northeast quarter of section 32, and another on the Anderson farm in section 36.

*Developments in White River Township in 1903.*—This is the township in which Winchester, the county seat, is located. Some light producers have been finished on the Clayton farm in section 9, three miles northeast of Farmland, but they developed much gas with the oil. A test on the A. Brown lease, six miles southeast of Winchester, developed a light showing of oil and some gas, the record of the bore being:

| | |
|---|---|
| Drive pipe | 227 feet |
| Casing | 335 feet |
| Top of Trenton | 1,113 feet |
| Total depth | 1,214 feet |

Two bores on the Pickett farm, two and a half miles southeast of Winchester, southwest quarter of 23, were finished in October and started in at about 20 barrels each. Their average record shows:

| | |
|---|---|
| Drive pipe | 85 feet |
| Casing | 226 feet |
| Top of Trenton | 1,091 feet |
| Total depth | 1,156 feet |

By January 1, 1904, they had produced 900 barrels of oil, and the indications of the new pool were sufficient to cause the Indiana Pipe Line Company to put in a line to them. A third bore on the same lease was a light producer, as was also one on the Hunt lease, in the south half of the same quarter section. The only other producing well in the township on January 1st, 1904, was on the E. Owens farm, northeast quarter of section 35, four miles southwest of Winchester, which yielded 100 barrels the first two weeks after its completion.

*Developments in West River Township During the Year 1903.* —Eight or ten test bores sunk in this township during the year resulted in dry holes or light gas wells. The only one showing oil was on the B. T. Olwin farm, in section 29, which yielded about two barrels a day after it was finished. Dry holes were drilled on the Haynes, Macy and Fletcher farms, section 20; on the Johnson farm, section 9, on the Lumkins farm, in 17, and on the Hawkins in 30.

A bore on the Courtner lease, section 25, Greene township, came in dry during the year, as did also several tests in Nettle Creek township; notably on the Clevenger and Lindsay farms in section 15. Outside of Monroe township all bores as yet sunk in Randolph County have been thousand to one shots and 95 per cent. of them have proven losing ventures.

## ISOLATED AREAS PRODUCING TRENTON ROCK PETROLEUM OUTSIDE THE MAIN INDIANA FIELD.

### In Wabash County.

The only productive area in this county has been in Noble township, on the west side where, in the vicinity of Kellar's Station or Rich Valley, a number of wells have been yielding

oil since 1897. During the year 1903 but four bores were completed in this area. Of these one was dry and the others came in as two to five-barrel producers.

In Waltz township, in the southwestern corner of the county and next to the Grant County line, a number of bores have been sunk in recent years by the Marion Gas Company, primarily in search of gas, one or two of which had a showing of oil. One, finished in April, 1903, on the Farley lease, northwest quarter of section 4, struck Trenton at 1,015 feet and developed an oil pay with a good showing at 1,035 feet. This continued for 23 feet, when a strong vein of salt water was encountered which filled the bore to within 100 feet of the surface. There being no gas for fuel and coal having to be hauled 8 miles from the nearest railway station, the well was never pumped. Another bore two miles farther north came in dry. A quarter of a mile west of the big gas well at Somerset a big salt water well was drilled in section 33, Waltz township, the vein of water being struck at 80 feet in Trenton. A bore which showed a trace of oil was also finished on the Garst lease in section 28, while dry holes were opened on the southeast of 23, and on the Hawkins farm in 25. Near Treaty, on the Big Four Railway, in Liberty township, three small producing wells have been opened, but no data is available as to their output or record.

### In Miami County.

The Peru oil field which created such a furor when opened in 1897, is practically a thing of the past. It was, in the main, a "town lot" development and the derricks on Flax Hill in places stood so thick that, in some instances, they had only a board fence between them. Thirty or more companies were drilling at one time within the city limits and a number of them finished as many as five wells and never sold a tank of oil. The rock was very porous and some of the wells were big producers, but so many on so small an area soon drained the reservoir. Of the 356 which were sunk, less than 30 are still in operation and the production has dropped from 50,000 barrels a month to less than 2,500. The best well in the pool, that on the Artis lot, started at 400 barrels a day and is still making 20 barrels. But two or three of the first companies in the field made any money, and more than a

quarter million of dollars was sunk by the unsuccessful ones. For a time the boom added much to the prosperity of Peru, as that sum was mainly put in circulation among its inhabitants.

A new pool was opened up in Erie township, three miles east of Peru, in 1898, which for a time had a vigorous growth, but its limits were soon defined and no new territory in that vicinity has recently been found. No bores were sunk in Peru, and but two in Erie township in 1903; both being on the Butts lease, where the majority of the best wells had previously been found. One developed a dry hole and the other came in as a five-barrel producer. The combined output of the Peru-Erie township-Rich Valley fields, in 1903, was but 63,838 barrels, distributed among the months as follows:

PRODUCTION OF THE PERU-RICH VALLEY TRENTON ROCK OIL FIELDS BY MONTHS FOR 1903.

| | |
|---|---|
| January | 4,790 |
| February | 4,874 |
| March | 5,456 |
| April | 4,556 |
| May | 4,695 |
| June | 6,526 |
| July | 5,904 |
| August | 5,855 |
| September | 6,117 |
| October | 5,511 |
| November | 5,823 |
| December | 3,731 |
| Total | 63,838 |

## In Allen County.

It was thought for a time that quite a pool of productive territory would be opened up near New Haven, Adams township, Allen County, but the results have not realized the expectations. A well drilled on the John Hartzell farm, northeast quarter of section 14 in 1899 made a fair showing of oil, but a second bore resulted in a dry hole. In February, 1903, a third bore was finished about 100 feet from No. 1, and came in as an 8-barrel producer, its record showing:

| | |
|---|---|
| Drive pipe | 96 feet |
| Casing | 700 feet |
| Top of Trenton | 1,440 feet |
| Total depth | 1,496 feet |

Quite a quantity of salt water was pumped with the oil. Two bores were drilled on the Mull lease adjoining that of Hartzell, one of which came in dry while the other started at three barrels. A dry hole was also finished on the Roullo farm in the same neighborhood, and another on the G. Doctor lease in section 33, which stopped further drilling in the township. A pipe line was laid from the two producers to New Haven, and 1,072 barrels of oil shipped from them during the year.

A test bore on the Dickason farm, section 3, Monroe township (29 N., 15 E.) in the southeast corner of Allen County, was drilled in October and came in with a large showing of oil and a big supply of gas. By accident the latter caught fire just before the drilling was completed and destroyed the derrick and burned to death the tool dresser. The tools were lost in the bore and at last accounts had not been recovered. One or two other very light wells had previously been completed in the vicinity. A mile west of Baldwin, in section 33, Jackson township, Allen County, a test bore was finished in October, which started at at about 18 barrels. The top of Trenton was reached at 1,402 feet. Still another bore, completed on the Amspaugh farm, section 3, Jackson township, is said to have started with an output of 12 barrels per day.

### In Hamilton County.

The only producing territory in this county is in Fall Creek township, in the southeast corner, near Fisher's Station, where several producing wells were sunk in 1900 and 1901. A number of dry holes have since been put down around them, four of which were drilled in 1903. The output of the producers for the entire year was 5,294 barrels. The pool is, as yet, a small one, and at present the chances of its increase in size seem remote.

### In Marion County.

The output of the Broad Ripple field in Washington township, Marion County, has been gradually decreasing for several years. No new bores were sunk in 1903, while three or four of the former producers were abandoned. The production of the Broad Ripple pool by months for the year 1903, was as follows:

OUTPUT OF THE BROAD RIPPLE, INDIANA, OIL FIELD BY MONTHS FOR THE YEAR 1903.

| | *Barrels.* |
|---|---|
| January | 491 |
| February | 486 |
| March | 357 |
| April | 1,135 |
| May | 1,059 |
| June | 799 |
| July | 534 |
| August | 727 |
| September | 559 |
| October | 668 |
| November | 724 |
| December | 587 |
| Total | 8,126 |

COST OF A PRODUCING WELL IN THE MAIN INDIANA OIL FIELD IN 1903.—On account of the increase in the price of lumber and iron tubing and piping, the cost of a producing well in the Trenton rock field of Indiana has slightly increased in recent years. A careful estimate of the average cost of drilling and fitting up the first productive well on a lease was made in both the Marion and Parker-Selma portions of the field in October, 1903. These estimates resulted as follows:

| | *Marion.* | *Parker-Selma.* |
|---|---|---|
| Rig or derrick | $420 | $425 |
| Drilling | 625 | 560 |
| Drive pipe | 160 | 120 |
| Casing | 165 | 110 |
| Shooting | 125 | 140 |
| Tubing and pumping outfit | 225 | 205 |
| Power house and power | 500 | 500 |
| Two tanks | 180 | 170 |
| Belting and lead lines | 125 | 125 |
| Incidentals | 100 | 100 |
| Total | $2.625 | $2.455 |

In the above estimate the price of drilling is put at 50 cents a foot plus the cost of fuel, which is extra and averages about $50 per well; that of 8-inch drive pipe at $1.05 in the Marion field and $1.10 in the Parker-Selma; 5½ casing at 37 cents in Marion and 32 cents in Parker-Selma; tubing at 15½ cents; sucker rods at 4½ cents in Marion and 3 cents in Parker-Selma; pumping

jack, $12, and shooting at 70 cents a quart; these being the ruling prices in the two fields. The incidentals include the cost of necessary teaming and the expenses (livery hire, board, etc.) of the operator or field manager while overseeing the work. The second well on the lease will cost about $1,200 less, as the rig, tanks, power house and power can be used for both wells, though there will be a loss of $125 in tearing down and rebuilding the derrick. It is not customary to build a power house until three or four producing wells have been finished on the lease, but if not built, an engine and boiler for pumping must be purchased for each productive well, which will cost $325 to $450. With the advanced methods of pumping by which oscillating pull wheels, rods, etc., are used, 20 or more wells can be connected to one power, and the cost of production be thereby greatly decreased.

No two wells in the field cost the same. One reason for this is that the length of drive pipe necessary is so variable, ranging from 25 to 450 feet. The number of feet of casing necessary also varies greatly in different parts of the field. In the Jay County field, the average well on a 10-well lease costs about $1,500, while in Grant and Huntington counties it runs about $1,750. Some operators use but one or two derricks on such a lease, putting in their stead, as fast as removed from a newly drilled productive well, a set of "derrick poles," costing from $10 to $15. Others leave the derrick over each well. These are often blown down or burned, thus causing a loss of $300 to $400. In many portions of the field an extra charge of 25 cents a foot is made by the driller for all drive pipe above 100 feet; and often also an extra charge of 25 to 50 cents for every foot over 50 feet into Trenton rock. The cost of the lead lines and surface rods on a lease will increase proportionally to the number of producing wells. In 1903 the price of a 2-inch lead line pipe was 13 cents, and of 3-inch, 24 cents a foot in the Indiana field; while that of surface rods was 4¼ cents per foot.

It has been claimed by promoters of Kansas oil properties that the cost of drilling in the Kansas field is much less than in Indiana, but the figures given out by the "Kansas Derrick" do not bear out this statement. According to that paper "The average depth of the Kansas well is 850 feet, and drilling costs 85 cents

a foot. The actual expense of completing and fitting up a producing well is about as follows:

| | |
|---|---|
| 850 feet drilling at 85 cents | $722 50 |
| 40 feet 8¼-inch casing at 63 cents | 25 20 |
| 300 feet 6¼-inch casing at 51½ cents | 154 50 |
| 700 feet 5-inch casing at 38½ cents | 269 50 |
| Shooting well | 45 00 |
| Tubing, 850 feet at 14 cents | 119 00 |
| Pumping outfit for walking beam | 22 00 |
| Sucker rods, 850 feet at 4¼ cents | 38 25 |
| 250-barrel tank, set up | 160 00 |
| Teaming | 45 00 |
| Total | $1,625 95 |

"The above figures are made up from actual basis on which material is purchased by the operators, and are sufficiently conservative, and to them should be added the expense of the party having the operations in charge. If a field manager, his salary and expenses must be taken into consideration, or if the party owning the lease is looking after the work, his board at $2.00 a day, buggy hire for getting to the property and other incidental expenses will foot up quite a considerable sum, not less than $50, and before the well can be put in service with other wells on the lease, if a pumping plant is installed, the cost of connecting up with the power must be considered, and also the proportionate cost of the pumping plant on the basis of the number of wells it is required to pump. As the wells are drilled almost entirely by machines, the expense of a derrick, which runs from $300 to $450 in the Eastern oil fields, is not included."

The above estimate does not include the cost of a power house, which has been added to the cost of an Indiana well, and includes the cost of but one tank, where two are absolutely necessary unless the pumping be stopped until the one tank can be emptied when it is full. Neither does it include the cost of lead lines and surface rods which is comprised in the Indiana estimate. If we add, therefore, to the estimate of the Derrick, $500 for power house, $160 for second tank (the price quoted by the Derrick); $125 for lead lines, etc., and $60 more for incidentals, we have a total of $2,470, which is equal to, if not greater than the cost of the first Indiana well. It is far wiser for those who are trying to induce capital to locate in any oil field, to give

figures which can be relied upon, rather than to try to convince people that the work can be done for one-half or two-thirds of the necessary outlay.

COST OF OPERATING A LEASE.—The cost of operating an oil lease after the production has been established need not be more than $100 per month, the salary of the pumper being $60, and the cost of fuel about $40. A dozen, or even 20 wells can, however, be operated almost as cheaply as one after they have been connected with the power. An extra pumper may have to be employed, but otherwise no additional expense is entailed.

Where the plant has been established, it will pay to pump as low as two or three wells, even if the yield is only two barrels each per day, provided the price of oil is as high as it was throughout the year 1903.

The estimate of expense and income from three two-barrel wells, after deducting the royalty of one-sixth, is as follows:

| | | |
|---|---|---|
| Income per month— | | |
| 150 barrels of oil at $1.15 (average price in 1903)..... | | $172 50 |
| Salary of pumper ..... | $60 00 | |
| Cost of fuel..... | 40 00 | |
| | ——— | 100 00 |
| Net income per month..... | | $72 50 |

With six two-barrel wells on the lease, the income would be $345, and the expense $100, a net gain of $245 per month.

From what has been written it will be seen that the cost of drilling and operating a lease in the Indiana Trenton rock field is as low or lower than elsewhere in the eastern United States for the following reasons: *(a)* The wells are comparatively shallow, the Trenton limestone in most instances being struck at less than 1,000 feet. *(b)* It is seldom that more than 150 feet of drive pipe and 400 feet of casing are necessary. *(c)* On account of a comparatively level surface a large number of wells can be connected to and pumped with one power. *(d)* Gas for fuel or for running gas engines is as yet available in many parts of the field, and if not present, coal is as cheap as in any other locality. *(e)* Transportation facilities are excellent, a system of pipe lines permeating all parts of the main field.

According to some of the leading operators, it costs 60 cents a barrel to produce oil on the average lease in the main Indiana

field. Whatever is received above that sum is net profit. If the lease is small the cost is much greater in proportion. Oil at $1.00 or more per barrel, therefore, brings a good price and a fair profit.

Whatever the price, the profits will depend largely upon the way the property is managed. Success as an oil operator depends upon the same watchful energy as brings success in any other business. One's pumps should be kept steadily at work so as to get all the oil possible. The drilling tools, lead pipes and pumping machinery should be kept in good repair; especially in late autumn should they be thoroughly overhauled and put in prime condition for the winter months. If the lead lines are left above ground or are but shallowly buried, they often freeze and burst. A poorly managed lease is liable to be tied up for a month or more on this account; while a neighboring lease which has everything in good shape for the winter produces nearly its normal output of oil.

To properly and profitably develop a lease the wells in average territory should be put down at intervals of 720x680 feet, which will bring eight wells on each 80-acre tract. In exceptionally good territory 10 bores can, with profit, be sunk on 80 acres, bringing them 551 feet apart each way. Above all, one should be on the look-out for overflow and leakage. Much of what would otherwise be profit in oil property is allowed to go to waste. Finally, if the property is inside the limits of productive territory, the successful oil man is he who lets other people do the wildcatting, and who follows where they lead.

NECESSITY OF GOOD ROADS IN OIL TERRITORY.—Good roads are necessary to the opening up and thorough development of any productive oil territory, and the sooner the farmer finds this out, the greater will be the income which he will derive from his royalty. The iron pipe, tubing and derrick timbers are all of heavy weight, and if the lease is some distance from a railway and the roads leading to it are of mud, as they are apt to be for four or five months if not graveled or macadamized, operations on the lease will necessarily be suspended for that length of time. Many a farm inside of productive territory in Indiana has not been drilled because the operator has noted that the roads leading to it would compel him to suspend developments from

November to April. He can not afford to be idle five-twelfths of his time, and so operates those leases along pikes over which he can haul his necessary supplies. The farmers living in the oil belt, who are receiving or might receive large sums in royalty for their oil, should, therefore, see to it that their farms are accessible at all times.

SOME BIG INDIANA OIL DEALS IN 1903.—The gradual rise in the price of Indiana Trenton Rock Oil from 43 cents per barrel in 1897 to $1.31 in 1903 has led to a corresponding increase in the price per barrel paid for settled production on leases which have been partly developed. In 1897 a company which had a lease of 160 or more acres with three or more fair wells on it could get only about $300 per barrel, daily settled production, for the property. In 1903 a thousand dollars per barrel, average daily production, was not an unusual price. More money has been made by many Indiana operators in thus partially developing and selling their leases to the larger companies than in any other way. In such a transaction the lease, which costs little or nothing in the beginning, but which has been proven productive by the test bores sunk on various parts of it, is counted the most valuable part of the property. It bears the same relation to the latter that a long term franchise bears to the assets of a street railway or other corporation.

Several noteworthy oil deals were made during the year 1903. In February the Senior Oil Company, of Bluffton, Indiana, sold its holdings in Randolph County, consisting of 1,224 acres of leases and five producing wells, for $225,000. The new owners, being Missouri capitalists, adopted the name "The St. Louis Oil Company," and immediately started in to spend $100,000 in the development of their property. The latter included the famous Cecil lease near Parker City, on which some of the biggest wells of the season were finished. Starting in with a daily production of only 260 barrels, by the end of the year they had 28 producing wells on the leases and an output of 1,100 barrels daily.

In the fore part of the year the Superior Oil Company sold its holdings in Grant and Huntington counties, consisting of 900 acres of leases and about 40 producing wells, for $120,000.

About the same time the Barnes Oil and Gas Company, of Marion, sold to some St. Louis parties 648 acres of leases, mostly in Grant County, and 15 producing wells, with a daily output of 45 barrels, for $50,000.

On June 1st, the Phœnix Oil Company, of Hartford City, sold 6,000 acres of leases, mostly in Washington township, Blackford County; on which were 90 producing wells with a 250-barrel net daily production, for $300,000. The new company immediately drilled in 50 new wells, and by November 1st had an output of 500 barrels daily.

A fortnight later the Ohio (Standard) Oil Company purchased the property of the Central Oil Company, in Grant, Wells and Huntington counties, consisting of 1,700 acres of leases, 147 producing wells, and 400 barrels net daily production, for $280,000 cash.

One of the largest deals of the year which, however, was in part a pooling of holdings, was that of the American Window Glass Company to the Columbia Oil and Gas Company, of Pittsburg. This sale was consummated October 1st, and by it 40,000 acres of leases in Blackford, Grant, Delaware, Jay and Hancock counties were turned over to the new company. On the leases were 149 producing oil wells, having a net daily output of 600 barrels, besides numerous gas wells and other holdings. The price paid was $2,000,000, and it is said that another half million will be at once spent in improving the property and sinking new wells, 400 of which will be put down as rapidly as possible.

## STATISTICS OF THE INDIANA TRENTON ROCK OIL FIELD FOR THE YEAR 1903.

The year 1903 maintained its record and set a new high water mark in the history of the Indiana Petroleum Industry. The price of Indiana oil was above the dollar mark during the entire year, while from October 17th to the end of the year it sold for a higher figure than ever before. As a consequence, the operators were stimulated to use their best endeavors to increase the output. New work went on rapidly and the number of bores

sunk was greater than in the preceding year, while the output far exceeded that for any previous year. Starting the year at $1.10 per barrel, it fell to $1.08 on January 21st, and the next day to $1.06, the minimum price of the season. On March 26th it was raised to $1.09 and on April 22d to $1.11. This price it held until May 16th, when it dropped to $1.09, at which figure it was sold until July 16th. Then a slow but steady increase in price set in until it reached a maximum of $1.33 on December 9th, which it held for 20 days. It then dropped to $1.31, the price at which it was selling on December 31st. The average price per barrel for the year, taking both time and amount received into consideration, was $1.14 as against 85.6c in 1902.

The total production of Trenton rock oil in 1903 was 9,161,331 barrels which, at the average price of $1.14 3-20, brought into the State $10,457,659. Compared with 1902, this was a gain of 1,625,770 barrels, or 21.6 per cent., as against a gain of 31.6 per cent. in 1902. However, on account of the high average price, the amount received by the producers was $4,007,219, or 62.1 per cent. more than in 1902.

The first of the following tables gives a complete record of the monthly production of petroleum from the Trenton limestone fields of Indiana for the 13 years beginning January 1, 1891, and ending December 31, 1903. This does not include the amount used in the field for fuel and other purposes; or that wasted by the burning of tanks or the leaking of pipes, but only that shipped or piped by the companies who purchase the oil from the operators. The second table shows the annual production, the average yearly price and the total value by years for the same period:

## I. TOTAL PRODUCTION OF TRENTON LIMESTONE PETROLEUM IN INDIANA FROM 1891 TO 1904, BY MONTHS.

(Barrels.)

| MONTH. | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | 1898. | 1899. | 1900. | 1901. | 1902. | 1903. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 6,171 | 15,841 | 111,824 | 259,000 | 300,568 | 365,582 | 290,746 | 317,014 | 297,291 | 353,451 | 425,140 | 554,038 | 651,355 |
| February | 5,981 | 18,946 | 96,025 | 232,107 | 230,559 | 241,743 | 309,922 | 272,780 | 220,440 | 302,493 | 384,735 | 460,073 | 568,789 |
| March | 5,159 | 24,794 | 134,549 | 282,376 | 310,303 | 386,586 | 341,961 | 325,301 | 290,257 | 364,590 | 432,922 | 573,412 | 724,969 |
| April | 4,973 | 26,184 | 146,493 | 287,330 | 352,077 | 395,032 | 328,779 | 310,034 | 325,774 | 381,804 | 447,261 | 579,711 | 680,921 |
| May | 5,757 | 31,033 | 186,939 | 321,502 | 397,001 | 417,963 | 340,023 | 311,208 | 344,831 | 426,363 | 482,118 | 635,752 | 751,348 |
| June | 8,136 | 40,888 | 209,616 | 333,479 | 403,569 | 434,167 | 369,803 | 320,477 | 334,282 | 446,492 | 481,807 | 633,452 | 809,438 |
| July | 10,809 | 49,203 | 221,666 | 327,349 | 434,376 | 422,968 | 375,249 | 314,861 | 329,086 | 437,087 | 506,065 | 696,911 | 831,005 |
| August | 11,603 | 56,109 | 248,353 | 345,031 | 420,132 | 407,238 | 371,921 | 332,777 | 347,621 | 466,127 | 523,106 | 697,040 | 838,615 |
| September | 16,500 | 66,034 | 245,615 | 319,588 | 409,169 | 415,675 | 362,528 | 326,264 | 332,283 | 418,716 | 519,087 | 672,611 | 857,117 |
| October | 19,029 | 95,699 | 252,568 | 339,424 | 393,153 | 394,283 | 408,179 | 319,490 | 326,781 | 467,521 | 532,960 | 725,973 | 873,160 |
| November | 20,801 | 129,270 | 245,607 | 304,030 | 373,789 | 337,331 | 430,958 | 300,644 | 326,802 | 406,684 | 510,788 | 656,457 | 778,323 |
| December | 21,715 | 144,067 | 236,038 | 337,450 | 361,436 | 362,164 | 423,069 | 300,457 | 332,266 | 441,347 | 479,485 | 650,131 | 796,291 |
| Totals | 136,634 | 698,068 | 2,335,293 | 3,688,666 | 4,386,132 | 4,680,732 | 4,353,138 | 3,751,307 | 3,807,714 | 4,912,675 | 5,725,474 | 7,535,561 | 9,161,331 |

## II. PRODUCTION OF TRENTON ROCK PETROLEUM IN INDIANA FROM 1891 TO 1904, WITH VALUE.

| | 1891. | 1892. | 1893. | 1894. | 1895. | 1896. | 1897. | 1898. | 1899. | 1900. | 1901. | 1902. | 1903. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total production (barrels of 42 gallons) | 136,634 | 698,068 | 2,335,293 | 3,688,666 | 4,386,132 | 4,680,732 | 4,353,138 | 3,751,307 | 3,807,714 | 4,912,675 | 5,725,474 | 7,535,561 | 9,161,331 |
| Total value at wells of all oils produced, excluding pipeage | $54,787 | $260,620 | $1,050,882 | $1,774,260 | $2,807,124 | $2,954,411 | $1,871,849 | $2,228,276 | $3,331,750 | $4,740,731 | $4,775,045 | $6,450,440 | $10,457,659 |
| Value per barrel | $0 40 | $0 37 | $0 45 | $0 48 | $0 64 | $0 63 | $0 43 | $0 59⅔ | $0 87½ | $0 96½ | $0 83⅓ | $0 85⅔ | $1 14 3/10 |

From the first of the above tables it will be seen that the largest production of Trenton rock petroleum in Indiana in any one month was in October, 1903, when 873,160 barrels were brought to the surface. The total production of Indiana Trenton rock oil for the twelve years reached the enormous sum of 55,172,755 barrels, which sold for $42,757,834, or an average of $3,289,064 per year.

In the third table there is shown the number of wells completed in Indiana by months from June, 1891, to January, 1904.

III. NUMBER OF WELLS COMPLETED IN THE INDIANA TRENTON LIMESTONE OIL FIELDS FROM 1891 TO 1904, BY MONTHS.

| YEAR. | Jan. | Feb. | Mar. | Apr. | May. | June. | July. | Aug. | Sept. | Oct. | Nov. | Dec. | Total. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1891 .... .... | ..... | ..... | ..... | ..... | ..... | ..... | 6 | 6 | 15 | 15 | 15 | 8 | 65 |
| 1892 ... .... | 11 | 13 | 18 | 13 | 17 | 19 | 17 | 30 | 25 | 52 | 33 | 47 | 295 |
| 1893 .... .... | 20 | 30 | 31 | 36 | 45 | 47 | 47 | 55 | 27 | 72 | 56 | 76 | 542 |
| 1894 .... .... | 90 | 103 | 103 | 80 | 110 | 107 | 84 | 123 | 100 | 107 | 97 | 85 | 1,189 |
| 1895 .... .... | 61 | 45 | 81 | 111 | 122 | 153 | 132 | 140 | 129 | 106 | 102 | 85 | 1,267 |
| 1896 .... .... | 76 | 90 | 86 | 136 | 148 | 150 | 113 | 121 | 70 | 58 | 66 | 66 | 1,180 |
| 1897 .... .... | 41 | 35 | 40 | 47 | 49 | 52 | 60 | 45 | 55 | 89 | 119 | 54 | 686 |
| 1898 .... .... | 41 | 23 | 29 | 43 | 38 | 55 | 53 | 80 | 72 | 82 | 92 | 86 | 694 |
| 1899 .... .... | 75 | 48 | 68 | 64 | 87 | 99 | 77 | 104 | 106 | 118 | 106 | 105 | 1,057 |
| 1900 .... .... | 113 | 67 | 98 | 148 | 165 | 163 | 158 | 155 | 135 | 152 | 118 | 108 | 1,580 |
| 1901 .... .... | 111 | 72 | 81 | 121 | 167 | 171 | 167 | 169 | 184 | 207 | 220 | 132 | 1,802 |
| 1902 .... .... | 176 | 113 | 169 | 182 | 247 | 297 | 288 | 279 | 323 | 295 | 320 | 243 | 2,932 |
| 1903 .... .... | 168 | 178 | 233 | 236 | 331 | 408 | 377 | 387 | 337 | 366 | 375 | 290 | 3,686 |
| Total.... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 16,975 |

From this table we learn that 754 more bores were sunk for oil in the Trenton rock fields of Indiana in 1903 than in any previous year. In 1902 the gain over 1901 was 1,130. The great majority of new bores were sunk in already proven territory by companies whose members were content to sink fair producing wells and develop what oil they could beneath their leases rather than seek far and wide for new territory which might produce a "gusher."

From the table it may also be learned that up to January 1, 1904, 16,975 bores had been drilled in the Trenton rock fields

of Indiana for oil alone. On that date there were 12,098 producing wells in the fields, as against 8,963 on January 1, 1903, a gain of 3,135 for the year. By subtraction it may be learned that of the total number of bores sunk for oil in the Trenton rock fields of the State, 4,877 have proven dry or have been abandoned as non-productive. The number abandoned in 1903 was 175, or 116 less than in 1902, while the number of dry holes drilled during the year was 376, or 66 less than in 1902. Of the total number of bores sunk in 1903, 10.2 per cent., or 4.9 per cent. less than in 1902, were dry.

On October 15, 1903, there were approximately 11,370 producing wells in the Trenton rock fields of the State. The production of oil for the entire month of October was 873,160 barrels, or an average of 2.48 barrels per well, for each day of the month. On December 15th there were 11,980 productive wells in the field. The output for the month of December was 796,291 barrels, or an average of 2.14 per well per day. The average output per well is always less during the winter months than during other seasons of the year. An average for the year would probably be about 2.35 barrels per well per day, a seemingly small amount yet totalling more than nine millions of barrels for the field for the year. These figures go to prove that the days of the gusher are practically over in the older portions of the main field where most of the bores were sunk. It is better for the practical producer that this is true. A well starting at 200 barrels or more a day creates an excitement and a rush for territory that, in the end, proves harmful to all concerned. Large bonuses are paid out and big risks taken which are foreign to territory whose wells are small but sure producers. As has been stated in my former reports, one large well will not make any man a fortune; twenty small ones may in time. The yield of the large producer will quickly grow much less; that of the twenty small ones will hold out for a long time. There is yet room for thousands of wells in the known productive territory. At present prices, eight to ten wells pumped by one power and yielding on an average but one and a half barrels each per day, will prove a paying investment.

The following table shows the number of producing wells, number of dry holes, total bores and average initial production of

wells drilled in each of the Trenton rock oil producing counties of Indiana in 1902 and 1903:

| County. | Producing Wells, 1902. | Producing Wells, 1903. | Dry Holes, 1902.* | Dry Holes, 1903.* | Total Bores, 1902. | Total Bores, 1903.* | Percentage of Dry Holes, 1902. | Percentage of Dry Holes, 1903. | Average Initial Production of Productive Wells, 1902. | Average Initial Production of Productive Wells, 1903. |
|---|---|---|---|---|---|---|---|---|---|---|
| Adams | 256 | 287 | 35 | 30 | 291 | 317 | 12. | 9.4 | 23. | 15.1 |
| Allen | 0 | 2 | 0 | 2 | 0 | 4 | 0. | 50. | 0. | 2 5 |
| Blackford | 283 | 353 | 75 | 41 | 358 | 394 | 21. | 10.4 | 15.7 | 11.1 |
| Delaware | 27 | 74 | 50 | 48 | 77 | 122 | 65. | 39.3 | 15.8 | 20.7 |
| Grant | 942 | 1289 | 108 | 94 | 1050 | 1383 | 10.2 | 6.8 | 18 5 | 15 1 |
| Hamilton | 1 | 0 | ..... | 7 | 1 | 7 | ..... | 100. | 12. | 0. |
| Huntington | 141 | 302 | 23 | 10 | 164 | 312 | 14. | 3.2 | 22. | 19.4 |
| Jay | 74 | 180 | 20 | 33 | 94 | 213 | 21.3 | 15.5 | 14.1 | 13.4 |
| Madison | 41 | 46 | 54 | 19 | 95 | 65 | 56.8 | 29.2 | 13.6 | 8. |
| Marion | 2 | 0 | 0 | 0 | 2 | 0 | 0. | 0. | 3. | 0. |
| Miami | 3 | 1 | 4 | 1 | 7 | 2 | 57.1 | 50. | 11.6 | 5. |
| Randolph | 26 | 78 | 33 | 50 | 59 | 128 | 55.9 | 39. | 23.1 | 43. |
| Wabash | 2 | 3 | 0 | 1 | 2 | 4 | 0. | 25. | 7.5 | 3. |
| Wells | 689 | 695 | 40 | 40 | 729 | 735 | 5.5 | 5.4 | 17.1 | 14. |
| Totals | 2487 | 3310 | 442 | 376 | 2929 | 3686 | †24.5 | †27.3 | †15.1 | †14.2 |

*These columns include bores sunk for oil which yielded gas.
†Denotes average.

From the table it will be seen that the average initial production for the year in the entire field fell off slightly, being 14.2 barrels per well as against 15.1 barrels in 1902.

The older producing counties have by far the best average record for the year, Huntington leading them all with an average initial output of 19.4 barrels, while its percentage of dry holes was but 3.2. Grant and Adams tied in average initial production, but the former holds the better record in dry holes, yielding but 6.8 against 9.4 per cent. for Adams. Wells holds its own remarkably well and stands next to Huntington in its low percentage of dry holes, while its average initial output was but 1.1 barrels less per well than that of Grant and Adams. Randolph led them all in average initial output, but nearly tied with Delaware for first place in the production of barren wells. From

a careful study of the table one can learn many other facts regarding the relative importance of each county in the field.

## CORNIFEROUS ROCK PETROLEUM.

The Corniferous formation is the lowest or oldest division of the Devonian system in Indiana, being represented in the State by sandstones with a maximum thickness of 20 feet, which are thought to correlate with the Schoharie group of New York, or by limestones 5 to 65 feet in thickness correlated with the Upper Helderberg. The waters in which the materials of the Corniferous limestone were deposited were clear and comparatively pure and in them sponges, corals, crinoids, trilobites and lower animal forms existed in great profusion. From the lime secreted by these marine forms the upper and purer beds of the Corniferous rock are mainly composed; and from the slow destructive distillation of the animals themselves a part of the oil contained in the formation was doubtless derived. The rocks of the Corniferous formation comprise the surface rocks of the State over a strip 5 to 40 miles in width, extending from the Ohio River at Jeffersonville north and northwestward to the vicinity of Logansport and Monticello. The outcrop of the eastern margin of the Corniferous passes through the following counties: Eastern Clark, Western Jefferson, Eastern Jennings, Central Decatur, Eastern Rush, Northeastern Hancock, Central Hamilton, Western Tipton, Southwestern Howard, Eastern Carroll and Eastern Cass. West of that margin the Corniferous is found either on the surface or underlying the later formations in all the counties. North of the Wabash River at Logansport, especially in Jasper and Laporte counties, the Corniferous has also been found in a number of deep bores sunk for oil, but on account of the thick mantle of overlying drift its exact limits are unknown.

Immediately above the Corniferous, west of its surface exposure, there is always found a thick bed of blackish or brownish shale, known as the Genesee or New Albany shale. This ranges in known thickness up to 195 feet and forms the necessary impervious cover which has retained the oil of the Corniferous in the parent rock. The Genesee shale is formed largely of the spores of low forms of fresh water or brackish marsh plants

known as Rhizocarps which flourished in vast numbers during the time the materials afterward compressed into the shale were being deposited. The shale is rich in bitumens derived from the destructive distilation of the spores of these ancient Rhizocraps. When kindled it will burn until they are consumed, and it is, therefore, by the unitiated, often mistaken for coal. These bitumens are, by natural processes sometimes separated from the shale and in the form of gas or petroleum are collected in reservoirs in it or in the underlying Corniferous formation. Much of the oil now being obtained from the Corniferous rocks may thus have entered that formation from the overlying shale.

Petroleum in commercial quantities has been found in the Corniferous rocks of Indiana at Terre Haute, Vigo County, in the vicinity of Birdseye, Dubois County, and northwest of Medarysville, Jasper County. The territory opened up at each of these points is, however, limited in area, and the output, except at Terre Haute, small in quantity.

THE TERRE HAUTE POOL IN 1903.—No new bores have been sunk in Terre Haute in recent years. The famous Phœnix well on a lot near the center of the city, still remains the oldest and best oil well in the State. Finished in May, 1889, it has produced an average of more than 1,000 barrels a month for 15 years. Its output last year was 11,553 barrels, which was sold by the owners mostly to local consumers, though a quantity was shipped in tank cars owned by the operators. Four other wells at Terre Haute are yielding oil, but only one, that operated by A. B. MeWhinney, in any quantity. During the year it produced 2,113 barrels, an average of about six barrels a day; while the other three wells yielded a total of only 274 barrels during the year.

The total output of the Terre Haute wells by months during the year 1903, was as follows:

PRODUCTION OF CORNIFEROUS ROCK OIL AT TERRE HAUTE, INDIANA, BY MONTHS, FOR THE YEAR 1903.

| | *Barrels* |
|---|---|
| January | 1,448 |
| February | 879 |
| March | 1,384 |
| April | 1,350 |
| May | 944 |
| June | 1,375 |

| | |
|---|---|
| July | 835 |
| August | 1,135 |
| September | 1,358 |
| October | 1,044 |
| November | 836 |
| December | 1,352 |
| Total | 13,940 |

There is little doubt but that a large quantity of oil occurs in the Corniferous rocks beneath the city of Terre Haute and vicinity, else the yield of the Phœnix well could not have been so uniform and long continued. The porous area or reservoir containing the oil must, however, be narrow, and this bore probably struck it at just the right point to get the best results. Some people who know little or nothing of the geology of Indiana believe that the Phœnix well struck a crevice which extends to the main oil field of the State. Such belief is of course preposterous, as the Corniferous rock which contains the oil at Terre Haute outcrops before the main oil field is reached, and is not pierced by any bore sunk in that field. Moreover, it is a younger and much thinner formation than the Trenton limestone, and for that reason there is little chance of developing an oil output near Terre Haute in any way comparing to that of the main Indiana field.

DEVELOPMENTS IN THE VICINITY OF BIRDSEYE IN 1902 AND 1903.—During the autumn of 1902 and the spring and summer of 1903 a number of bores were sunk for oil in the vicinity of Birdseye, a town in the southeastern corner of Dubois County. In some of the bores quite a quantity of oil was developed in the Corniferous limestone, but the wells were sunk too far apart, one from another, to pump with profit. As a consequence the field, as yet, counts for but little in the petroleum industry of the State.

The first bore put down was on the Henry Eckert lease in the southwest quarter of section 24 (3 S., 3 W.), six miles south of Birdseye in Perry County. The Southern Oil Company of Evansville, Indiana, sunk this bore on account of supposed "surface indications" in the way of seepage, and scum of oil on nearby springs. It is also alleged that the late Prof. Edward Orton, of Ohio, had predicted that oil would be found in this region. The bore was finished in September, 1902, at a cost of $2,600, with the following record:

| | |
|---|---|
| Drive pipe | 40 feet |
| Casing | 595 feet |
| Top of pay | 1,010 feet |
| Total depth | 1,030 feet |

In a limestone between 300 and 400 feet below the surface there was a small showing of a light colored oil, which was also found in most of the bores afterward sunk in the vicinity. The well, when finished and shot with 160 quarts, was put to pumping and made 15 barrels of oil a day for two days and then slowly settled to 3 barrels at the end of two weeks. It was being pumped with the contractor's power, and as he wished to remove it to another location, the pumping was stopped and has not been renewed; the oil produced still being in the tanks in October, 1903.

The strike, like all others of any consequence in a new field, attracted much attention, and thousands of acres of leases were at once secured within a radius of 10 miles. A number of new bores were at once begun, the second well finished being on the Gerhard Gellhausen lease, a mile and a quarter southeast of the first, in the southeast quarter of section 26 (3 S., 3 W.). It came in as a salt water hole without a showing of oil and with the following record:

| | |
|---|---|
| Drive pipe | 10 feet |
| Casing | 725 feet |
| Total depth | 1,280 feet |

The third bore, sunk by the original company, was on the C. Hartwick farm in the northeast quarter of the southwest quarter of 19 (3 S., 2 W.), about one-half mile east of No. 1 Eckert. It was finished in March, 1903, coming in, it is claimed, as a better producer than No. 1, its record being as follows:

| | |
|---|---|
| Drive pipe | 60 feet |
| Casing | 600 feet |
| Total depth | 1,040 feet |

The roads in the vicinity being extremely bad, no tank was on the ground, so the contractor pumped the well for three hours into the nearby creek, and estimated its output at 60 barrels. However, the company, being new in the oil business, were looking for a "big well" of the gusher variety. They did not consider

the new well good enough to put in a special power to pump, so, leaving the rig and pump, they started their No. 4 bore. This was in Dubois County, on the J. C. Kitterman lease in the northeast quarter of 36 (2 S., 3 W.), about one and a half miles southeast of Birdseye. Here a bore was started on the side of a bluff of Anderson Creek instead of on the level land of the valley of that stream; the theory of the field manager being that there was a crevice in the underlying rock of the valley which had caused the stream to follow its present bed. Wishing to avoid this supposed crevice, the well was located on an almost inaccessible spot, 50 feet above the level lowland. It was finished in May, 1903, and proved to be the best well at any time completed in the field, its record showing:

| | |
|---|---|
| Drive pipe | 92 feet |
| Casing | 702 feet |
| First pay | 981 feet |
| Total depth | 1,000 feet |

The oil pay streak was 19 feet thick; and when the first screw was finished the oil stood 400 feet in the bore. As the pay was very porous the well was shot with but 60 quarts. The shot caused the casing to collapse and it was six weeks before the well was cleaned and put to pumping. It then made 35 barrels the first day, 20 the second, 10 the third, and settled down to a 5-barrel producer at the end of three weeks. No pipe line or other means of transportation being present, the well was closed down ready for pumping and remains in that condition, the derrick, etc., still in place.

No. 5 bore of the Southern Oil Company was No. 2 on the Hartwick lease, located in the northwest of the northwest of 19 (3 S., 2 W.), one-third of a mile northwest of No. 1 Hartwick. At a depth of 995 feet the oil pay was found, but was only five feet thick. The oil rose 40 feet on the stem, but salt water soon developed and drowned it out. The well was not shot, and was abandoned after the casing was pulled.

A sixth bore was sunk by the Southern Company on the southeast quarter of section 23 (2 S., 3 W.), three-quarters of a mile northwest of Birdseye. It was completed in November, 1903, and came in as a small producer.

In addition to the six bores sunk by the Southern Oil Company, six others were put down by the Ohio (Standard) Oil Company, in the Birdseye field, as follows:

No. 1. On Mart. Eckert lease, southeast quarter of 15 (3 S., 3 W.), Dubois County, about five miles southwest of Birdseye. Top of pay at 1,015 feet. Came in as a 15-barrel well and pumped 36 hours.

No. 2. On Dixon lease, northeast quarter of 3 (4 S., 3 W.), Perry County, two and a half miles from Siberia postoffice. Drilled to a depth of 1,600 feet. No showing of oil.

No. 3. On Chanler & Brown lease, southwest quarter of section 3 (3 S., 3 W.), Dubois County, two and a half miles southwest of Birdseye. When completed started at 30 barrels, but dropped to nothing in a short time.

No. 4. On Bombolaski lease, northeast of 22 (3 S., 3 W.), 600 feet south of No. 1 Eckert. Dry hole.

No. 5. On Jackson lease, southwest quarter of section 12 (3 S., 3 W.), Dubois County. Came in as a good gas well but with very little showing of oil. On attempting to drill deeper, salt water came in with a rush and drowned out the gas.

No. 6. On the Kiser lease, south half of section 16 (2 S., 2 W.), Crawford County, about three miles northeast of Birdseye. Came in with fair showing but not enough to pay for pumping.

On October 14, 1903, five of the wells put down by the Ohio Oil Company had been abandoned, while the No. 1 Eckert was still standing, as finished, with a quantity of oil in the tank.

In addition to the 12 bores above mentioned, the Highland Investment Company of Chicago, put down another on the Marion Eckert farm, southwest of 14 (3 S., 3 W.), 500 feet east of the Ohio Company's No. 1 Eckert. This bore developed a fair showing of oil, and after shooting was pumped several days into the tank of the Ohio Company's well to the west.

From the above account it will be seen that of the 13 bores sunk to date in the Birdseye field, seven came in as light to fair producers, three as dry holes, one as a gas well and two with a small showing of oil. If the seven producers, or even three or four of them, had been put down close enough together to connect with one power, there is little doubt but that they would have produced a large quantity of oil. Being most of them several miles

apart, and with no pipe line in the field, it would not pay to pump them with separate power. The Southern Oil Company should have drilled its second and third wells on the Eckert lease where its No. 1 was located, and its fifth and sixth wells on the Kitterman lease adjoining its No. 4. If the latter had been sunk 300 feet south, on the level bottom land of Anderson Creek, it would doubtless have been as good a producer, and a half dozen or more wells, if necessary, could have been connected up with it. It never pays, when one has a fair well completed, to go a mile or two away in search of a "gusher." As it is, $50,000 or more have been sunk by the three companies in the field, and not a dollar's worth of oil has been sold.

The pay streak in which the oil is found in the Birdseye field is a bluish gray limestone, coarsely crystalline in structure. Pieces from the Kitterman well contain a number of small globular cavities, partially filled with crystals of calcite. The oil bearing stratum is usually found 10 to 15 feet below the top of the bed of limestone in which it occurs. Immediately overlying the latter is a bed of soft, black to brown shale, 10 to 40 feet in thickness. There is no doubt but that the latter is the Genesee shale which, as above mentioned, overlies the Corniferous in the western two-thirds of the State. The limestone containing the pay streak differs in color and structure from the Trenton, and also effervesces more freely. It is without doubt the Corniferous limestone, the samples being identical in structure and color with the outcrops of Corniferous in Clark County.

The oil produced in the Birdseye field was examined for the Southern Oil Company by the chemist of the St. Louis Sampling and Testing works, who reported on it as follows:

COMPOSITION OF CRUDE OIL FROM BIRDSEYE, INDIANA.

| | |
|---|---|
| "Light oils below 150° C..... | 17.4 per cent. |
| Illuminating oil between 150° and 300°..... | 26.9 per cent. |
| Lubricating oil above 300° C..... | 42.2 per cent. |
| Residuum ..... | 13.3 per cent. |
| | 100 per cent. |

"Began to distill at about 45°C. Ceased to distill at about 350°C. Specific gravity, 0.850 at (16°C.).

"The analysis shows it to be a very good grade of petroleum for the manufacture of light oils (naphtha, gasoline, etc.), and illuminating oil. The percentage of light oils being 17.4 per cent. and of illuminating oil 26.9 per cent. and with the method now employed of destructive distillation or 'cracking' the percentage of illuminating oil would be largely increased to upwards of 60 per cent. but at the expense of much of the lubricating oil. The residuum amounting to 13.3 per cent. consists mainly of coke."

Bore at Taswell, Crawford County, Indiana.—During the winter and spring of 1903, the Highland Investment Company, of Chicago, sunk a bore in search of gas or oil near the eastern limits of the town of Taswell, eight miles east of Birdseye, on the Southern Railway. Since this bore was put down in hitherto untested territory, I include the following account of it which was kindly furnished me by Mr. A. L. Nestlerode of Chicago, the field manager of the company: "Beginning at a point 810 feet above sea level we used but 12 feet of drive pipe, when we struck a bed of sandstone, and from that point went through slate and sandstone alternately to a depth of 254 feet, where we struck a bed of Carboniferous rock nine feet thick. At a depth of 272 feet we struck a similar bed of the same thickness. We found no limestone until we arrived at a depth of 425 feet. From this point we had alternate layers of slate and limestone to a depth of 830 feet, where we struck another layer, 45 feet thick, of the Carboniferous rock. At a depth of 975 feet we cased the bore with 6¼-inch casing, but at 1,123 feet we struck a very heavy flow of salt water. We continued drilling, and at a depth of 1,300 feet put in a string of 5⅝-inch casing just 1,300 feet in length, and had a dry hole from this point on. We expected to strike the Trenton rock somewhere about 1,325 feet, but at a depth of 1,310 feet we encountered what the drillers at Birdseye called 'shale' but which was black limestone with considerable pyrites of iron in it, and so hard that the drill had to be dressed at every screw. At a depth of 1,460 feet we struck what the Birdseye drillers called 'Trenton Rock.' It was the formation in which they found their oil, but we had only a very strong smell of oil, while a white substance looking like refined oil gathered on the surface of the water. Our contractor, who was a Trenton Rock driller of northern Indiana, insisted that we had as yet struck neither shale nor Trenton

rock, but at a depth of 1,565 feet we struck an elegant brown shale. This continued to a depth of 1,690 feet where we encountered the actual Trenton rock and drilled into it 100 feet, or a total depth of 1,790 feet. In drilling through the Trenton rock we again encountered the refined looking oil and an odor that greatly excited us, for it smelled just as if each bailer full of the material was full of the real petroleum, but we got neither gas nor oil. We did not shoot the well, a fact which we now keenly regret."

It would appear from the above statement that the distance between the Corniferous and Trenton limestones at Taswell is but 230 feet. However, I saw no sample of drillings from the well, and hence can not vouch for the accuracy of the statement that the formation in which the drilling stopped was Trenton limestone.

Bore in Lane Township, Warrick County, Indiana.—A bore was sunk in the spring of 1903 on the Riley Wilson lease, northeast quarter of section 8 (4 S., 7 W.), a mile and a quarter south of Scalesville, Warrick County; and 13 miles northeast of Boonville, the county seat. Its record was as follows:

| | |
|---|---|
| Drive pipe | 40 feet |
| Casing (6¼ in.) | 980 feet |
| Casing (4¼ in.) | 1,045 feet |
| Total depth | 1,168 feet |

The last drilling was in a white sandstone, which had been pierced 34 feet when a strong salt water vein was tapped which filled the bore. The diameter of the latter was too small at the beginning to admit of farther casing, hence the well was abandoned before reaching Trenton, and with no trace of a productive "sand." It is claimed that five veins of coal, varying in thickness from 4 to 11 feet, were encountered in the bore; one of them being a 7-foot vein of cannel coal.

The Jasper County Oil Field in 1903.—Since 1899 a number of shallow bores in Jasper County have been producing more or less petroleum. A full account of the history of this field was given in the report of this Department for 1900.

The oil is found in a limestone which, without doubt, is a continuation of the Corniferous limestone formation at present producing oil in the Canadian fields, and at Terre Haute, Indiana;

the limestone being easily recognized throughout a large area of southern Michigan and western Indiana, but being entirely absent in the eastern and central portions of the latter state. The formation is nearest the surface in the section of Indiana which has since developed into the Jasper County oil field, and is found in the most productive portions of this field at approximately 100 feet below the surface.

In eastern Jasper, western Pulaski and the counties to the northward, the New Albany or Genesee brown and black shales immediately underlie the drift and are encounterd in sinking wells for water. As already noted, these shales are rich in bitumens, both oily and gaseous. The Corniferous limestone or oil-bearing rock, underlying this shale in the productive area of Jasper County, is a hard gray limestone which, in a number of test wells which have been drilled through the formation, has been found to be approximately 40 feet in thickness. The upper 20 feet, however, constitutes the oil producing portion of the limestone, and in this 20 feet are found several bands or pay streaks of porous rock which enlarge into crevices with considerable regularity. These crevices are often lined with pyrites of iron and lime crystals. Crevices have been found in quite a number of the producing wells which were two or three feet in thickness. In case a well, while being drilled, encounters one of these crevices, it will often produce a considerable quantity of oil without a shot of nitroglycerine, but almost without exception it has been found desirable to place a torpedo of about 20 quarts in such a position in the formation as to cover 10 or 12 feet of rock, the result invariably being to greatly increase the well's production. One of the large glycerine companies has a magazine in this district and provides the Jasper County producer with the necessary explosive.

The usual formation encountered in drilling a Jasper County well is as follows: Drift, consisting of sand, clay and loam, 50 feet, under which is encountered a bed, 45 to 55 feet in thickness, of close-grained black shale which forms an impervious cover for the Corniferous limestone reservoir. This black shale or slate does not cave in drilling, it thus being necessary to use but a short length of drive pipe to shut off the drift formation. The operators use for this purpose 5⅝-inch casing, and by driving it a sufficient distance into the black shale shut off the surface water. With

the usual form of portable drilling machine employed in the Jasper County district, an expert crew has completed a bore in the remarkably short time of 23 hours actual drilling time, it thus being evident that the cost of a well is a very small sum.

The oil obtained is unlike any other product found in the Ohio and Indiana oil districts, it being of a black or very dark green color and of a gravity which ranges from 17 to 21. Its thickness and low gravity is, without doubt, largely due to the shallow depth at which it is found, the more volatile portions having long since escaped through their overlying formations. The oil on examination is found to have a cold test of about 7 degrees F. and a fire test of over 400 degrees. It has a good viscosity test, and is universally used throughout the Jasper County district for lubricating purposes. It is associated with a strong sulphur water of which a large amount is usually encountered whenever a crevice is penetrated. There is usually but little gas found in the district except immediately upon the completion of a new well, when, for several days following, a considerable quantity of gas is often discharged.

An analysis of a sample of the Jasper County oil was made for Mr. E. T. Mudge, of Chicago, by Mariner & Hoskins of that city, who reported on it as follows:

"ANALYSIS OF CRUDE PETROLEUM FROM THE JASPER COUNTY, INDIANA, OIL FIELD.

| | |
|---|---|
| Specific gravity | 0.928 or 20.8° Beaume |
| Cold test | 7° F. |
| Flashing point | 410° F. |
| Fire test | 437° F. |
| Sulphur | 1.26 per cent. |
| Asphaltic matter | 2.90 per cent. |

"This oil contains no light oils, and it is not possible to fractionate it, except in a vacuum apparatus. It is, in fact, with the exception of a small amount of asphaltic matter, a desirable lubricating oil, and it is unusual to find less asphaltic matter, than that reported, in crude lubricating oils. It might be added, therefore, that this oil contains approximately 97 per cent. of lubricating oil." *M. & H.*

Statements from numerous engineers who have given the oil thorough tests as a lubricant all certify to its high standard for that purpose.

The Federal Oil and Asphaltum Company, of England—the Byrd Syndicate of my former report—on January 1st, 1904, had 302 completed wells in the Jasper County field. Of these they were pumping but 80, and were delivering about 125 barrels of oil per day to the Indiana Asphaltum Company, at Asphaltum, a station on a branch or spur of a railway which penetrates the main field. This station is 12 miles south of Kersey, a junction point on the I. I. I. Railway. At Asphaltum a refinery capable of utilizing 300 barrels daily of the crude oil was completed in September, 1903. Lubricating oil and asphalt are the only two products of the refinery. Several grades of the lubricating oil are made. The residue or asphaltum has a high melting point and it is sold mainly for roofing purposes. The oil is first pumped from the producing wells into central tanks and then run to the refinery. In the winter season it has to be hauled in tank wagons on account of its viscosity. About 6,200 barrels were in stock when the refinery was completed, this being very nearly the total production of the field up to that date. The Indiana Asphaltum Company was paying $1.10 per barrel in the open market on January 1st, 1904, but their contract price with the English company was for a less sum.

The Jasper County oil is all produced in a small area in Gillam township, the wells of the Federal company being mainly located on the south half of section 29; the southeast quarter of section 32 and all of section 33 (31 N., 5 W.). Aside from this area, E. T. Mudge had 46 wells, 12 of which were pumping, in section 28 of the same township. The average output per well in the summer season is about 1½ barrels. The best well in the field is said to be No. 6 Gifford, which averaged, when pumped, six barrels per day for nearly three years. The Asphaltum company secured 2,050 barrels of stored oil, the output of this well to September, 1903.

There is probably no oil field in the world in which the expense of development is as low as in the Jasper County district. The oil formation lies at an extremely shallow depth, and the area which has been found to be petroliferous seems to be fairly uniform in character, resulting in few wells which are non-productive.

## HURON SANDSTONE PETROLEUM.

Within recent years petroleum has been found in commercial quantities in a sandstone in southwestern Indiana. From the record of the bores and the appearance and structure of the oil-bearing rock, the latter is probably one of the sandstones of the Huron Group.* This formation or group comprises the uppermost or latest rocks laid down during the Lower (Sub) Carboniferous period. It is composed of three beds of limestone with two intervening beds of sandstone, their combined thickness reaching a total of 150 feet. The Huron comprises the surface rock over a strip 2 to 15 miles in width, which covers a part of eight counties in southwestern Indiana, as follows: Western Crawford, eastern Perry, central and northwestern Orange, eastern Martin, western Lawrence, eastern Greene, western Monroe and central Owen. Immediately overlying the Huron to the west is the Mansfield sandstone or "Millstone Grit," a massive sandstone, ranging up to 150 feet in thickness, which is the basal formation of the Carboniferous rocks of the State.

A typical section of the Huron group, exposed near Foote's Spring, Orange County, southwest quarter of section 11, (1 N., 2 W.), obtained by Mr. Kindle for the Twentieth report of this Department, was as follows:

| | |
|---|---|
| Slope with Mansfield sandstone fragments | 18 feet |
| Upper Huron limestone | 15 feet |
| Upper Huron sandstone | 35 feet |
| Middle Huron limestone | 16 feet |
| Lower Huron sandstone | 30 feet |
| Lower Huron limestone | 6 feet |

Of the sandstones of this group, which comprise the formation yielding the oil, Mr. Kindle says: "These beds, which are separated by the Middle Huron limestone, vary widely in thickness and in lithological characters. They are composed of strata of sandstone of medium coarseness, buff to light gray or white in color. In many places, iron in the form of limonite concretions occurs in the massive sandstone. Thin seams of coal, three to six inches in thickness, are found in them at some localities. Beds of shale, sometimes in part replace the sandstones."

*For a full discussion of this group see the 27th Ann. Rept. of this Dept., pp. 71 et seq.

Oil in commercial quantities has been found in the Huron sandstone near Loogootee, Martin County, and near Princeton, Gibson County.

THE LOOGOOTEE PETROLEUM FIELD.—In 1899 and 1900, 26 bores were sunk to one of the Huron sandstones near Loogootee, in search of gas or oil. Of these, 3 produced oil, 10 gas, the remaining 13 being dry. The results showed that in that region the productive stratum of sandstone is not to be relied upon. It does not appear to be continuous, but is in pockets. It varies much in thickness and also in closeness of texture, in some places being soft, quite porous and productive; in others hard, close-grained and barren. In an account of the Loogootee field, written in the spring of 1901, I gave it as my opinion that, on account of its pockety nature and thinness the supply of oil from any given area of the productive sandstone near Loogootee will never equal that from any similar area of the main Trenton limestone field of northeastern Indiana. Subsequent operations have borne out this opinion. Two producing bores, sunk in 1901, started at seven barrels each, while one in 1902 was dry. The records of the producing wells in the vicinity of Loogootee showed:

| | |
|---|---|
| Drive pipe | 15 to 20 feet |
| Casing | 480 feet |
| Top of oil sand | 473 to 524 feet |
| Total depth | 485 to 543 feet |

The pay streak in which the oil occurs is a fine to coarse-grained drab colored sandstone, varying in thickness from 3 to 14 feet. A number of the wells are still yielding a large amount of gas, while several wells, formerly gas producing, now have a small output of oil. In November, 1903, nine wells were being pumped in the Loogootee field, the total daily output being but six barrels. Three of the wells were on the Cannon farm, northwest quarter of section 30, Perry township, three-quarters of a mile southeast of Loogootee; the other six on the Larkin lease, southwest quarter of section 19, a half mile southeast of the town. The total output of the wells for the year 1903, according to figures furnished by the Indiana Pipe Line Company, was 1,459 barrels.

THE PRINCETON PETROLEUM FIELD IN 1903.—For a number of years it has been thought that petroleum existed in commercial quantities in the vicinity of Princeton, the county seat of Gibson

County. Small deposits of asphaltum encountered in several places in a deep coal mine operated near that city led to the belief that the more volatile petroleum would eventually be found. Finally, in 1901, the Interstate Gas & Oil Company was organized and began the sinking of a deep bore on the Brownlee farm, southeast corner of section 1 (2 S., 11 W.), one-half mile north of the corporate limits of Princeton. It was first intended to drill to the Trenton limestone, but the surface opening was too small and the caves in the shales passed through too numerous to permit the reaching of that limestone. The drill passed through alternating layers of shale, coal, fire-clay, limestone, etc., and after reaching a depth of 1,453 feet the bore was abandoned, mainly on account of a bad cave in the shale. A deposit of asphaltum, said to be six feet in thickness, was struck at a depth of 450 feet and fair showings of oil at 850 and 995 feet.

After the abandonment of the well a new company, styled the "Hoosier Prospecting Company" was organized, mainly for the purpose of developing the deposit of asphaltum, which it was thought was of sufficient size to be valuable. Leases on 700 acres of land just west of Princeton were obtained and a bore started which developed into the first productive oil well in the Princeton field. It was located on the southeast quarter of section 2 (2 S., 11 W.), one and a half miles west of Princeton, and finished May 25, 1903. The strata passed through were alternating layers of sandstone, limestone, shale and coal, varying in thickness from 1 to 134 feet. All belonged to the Upper Carboniferous series of rocks. Five veins of coal were pierced, one of which, nine feet in thickness, was struck at a depth of 785 feet. The depth of the well to the top of the oil bearing sandstone was 871 feet. The record of the bore, in the vernacular of the oil man, was:

| | |
|---|---|
| Drive pipe | 60 feet |
| Casing | 802 feet |
| Oil pay | 871 feet |
| Total depth | 907 feet |

When finished, the oil rose nearly to the top of the bore, but the well was not put to pumping for several months.

A second bore was soon begun on the same lease, 800 feet northeast of No. 1, but was not completed until August. Its record showed:

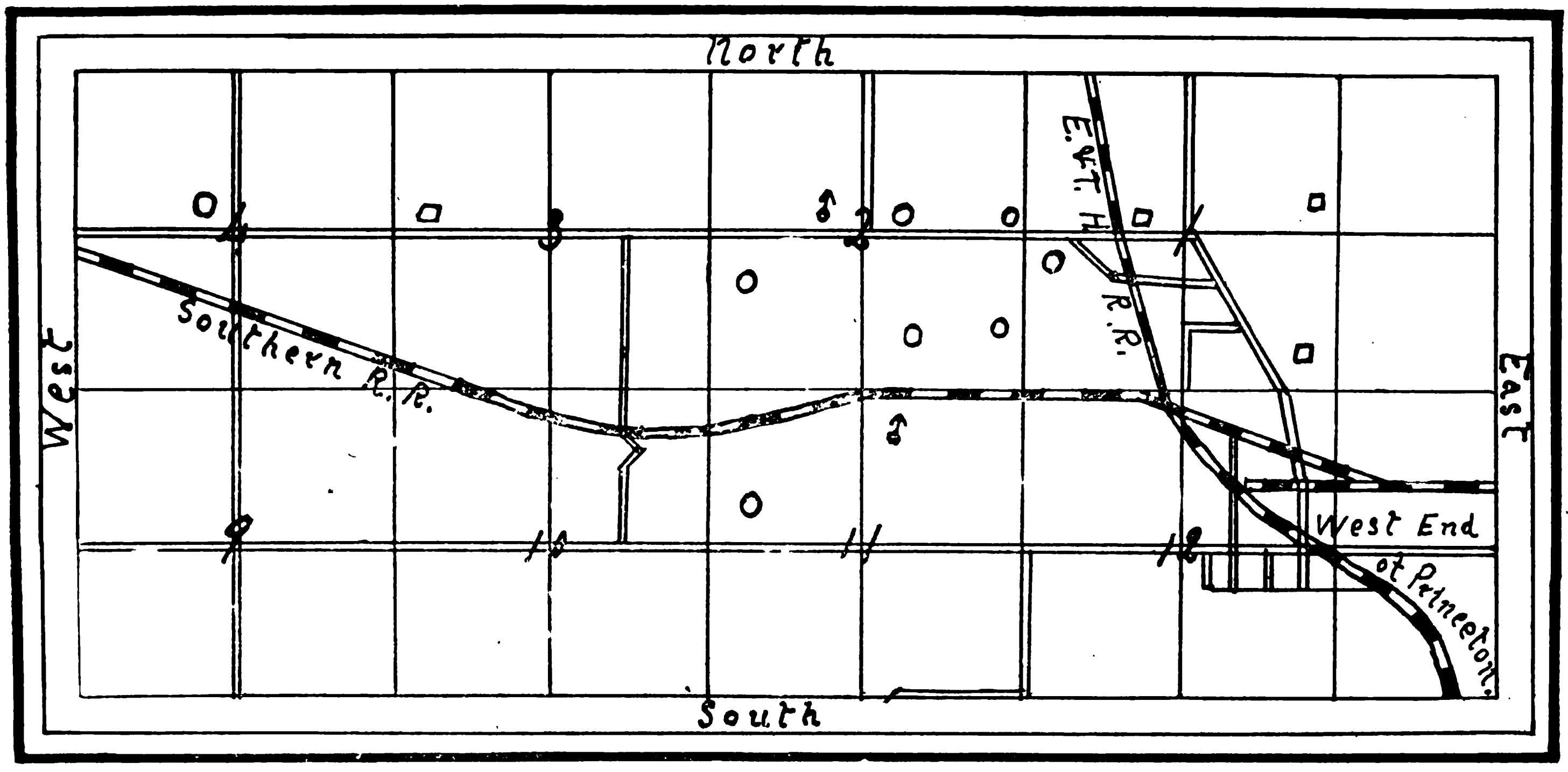
| | |
|---|---|
| Drive pipe (10-in.) | 40 feet |
| Casing (8-in.) | 60 feet |
| Casing (6¼-in.) | 584 feet |
| Casing (4⅞-in.) | 804 feet |

The shale immediately overlying the oil pay in No. 1 was continuous, and 62 feet in thickness, but in No. 2 there were two strata of nonproductive sandstone in this shale before the oil pay was reached. One 10 feet in thickness was found 20 feet in the shale. The second, five feet thick, was 35 feet below the top of shale. The third layer of sandstone had the upper 12 feet barren, but the lower six feet proved to be quite rich in oil. Quite a quantity of gas was also present and sprayed the oil above the top of the derrick. A light shot was used, and the production started at 25 barrels per day. The well flowed naturally for some time and was put to pumping about September 15. On October 13 the two wells on the lease were producing about 9 barrels of oil a day.

The bringing in of a second productive well was heralded far and wide, and caused an influx of oil operators from every direction. The country was scoured for leases, and by the middle of October 16 companies had been organized and a half dozen derricks were up. The third well completed was on the Woods lease, northwest corner of the southwest quarter of section 1. It produced quite a quantity of gas and about eight barrels of oil.

Before the end of the year the Ohio (Standard) Oil Company had completed two bores on the Mumford, south half of the northeast quarter of 2, one of which started at 25 barrels, but settled to eight in about ten days. In it the top of the oil-producing sand was found at 913 feet, and the oil between 918 and 930 feet. There was 47 feet of this first sand stratum, the lower portion of which was barren. Then followed a layer of shale, eight feet in thickness, below which was another layer of sandstone, 48 feet thick. At a depth of 1,088 feet a strong vein of salt water was encountered and the drilling stopped. No. 2 well, a quarter of a mile west, was a light producer, starting at about ten barrels.

A bore on the Downey lease in the southeast corner of the northwest quarter of section 2 produced quite a quantity of gas, but was practically barren of oil. A dry hole was drilled just east of the cemetery north of Princeton, in the northeast quarter of




The Princeton Oil Field on Jan. 1st 1904.

O=Productive Oil Wells. □=Dry Holes. ↑=Gas Wells.

section 1, and another on the Howe lease, close to the E. & T. H. Railway, in the northwest quarter of the same section. Of two bores just south of the Southern Railway, in the north half of section 11, one on the Emerson farm resulted in a small producer, while the other, on the Woodham lease, yielded a quantity of gas.

The best well in the field, up to January 1, 1904, was No. 1 on the Geiser lease, northwest quarter of the southwest quarter of 2. When shot it flowed 75 barrels for a day or two, but soon settled down to a 20-barrel producer. Its record showed:

| | |
|---|---|
| Drive pipe (10-in.) | 60 feet |
| Casing (8-in.) | 80 feet |
| Casing (6¼-in.) | 600 feet |
| Casing (4⅞-in.) | 800 feet |
| Top of oil sand | 908 feet |
| Total depth | 978 feet |

A bore on the Kelch lease in section 27, White River township, five miles northwest of Princeton, came in dry. A light well was finished on the Blair farm on the southeast corner of the northwest quarter of section 4, and a dry hole on the Mauch lease in the southwest corner of the northwest quarter of section 3 (2 S., 11 W.). An important test bore put down on the Rogers lease, northeast quarter of section 27 (1 S., 12 W.), nine miles west of Princeton, produced only a small amount of gas. From the above it will be seen that operations to the close of the year 1903, resulted in eight producing wells, six dry holes and two gas wells. About a dozen rigs were up for new wells in various parts of the territory on January 1, 1904, and the field will doubtless be thoroughly tested before the close of that year.

The oil of the Princeton field is found in a bluish gray sharp-grained sandstone, which is doubtless one of the Huron sandstones immediately underlying the Mansfield sandstone or Millstone grit. The formation is the same as that in which the Loogootee oil occurs, 45 miles to the northeast. At Loogootee the top of the oil-bearing stratum is found at an average depth of about 500 feet below the surface, while at Princeton the average is approximately 890 feet, showing a dip of nearly nine feet to the mile between the two points. The records of the wells in the vicinity of Princeton show a local dip in the oil-bearing sandstone of a little more than five feet to the mile to the southwest. The later

wells sunk in the Princeton field have found the best productive portion of the sandstone 25 to 40 feet below the top. Much trouble is experienced with the numerous shales passed through, as all of them are soft and friable and very likely to cave. For this reason most of the wells have to be cased nearly to the top of the productive sand.

The oil found in the Princeton field is darker and thicker than that yielded by the Trenton rock. It registers 31° Beaumé and its percentage of illuminants is low; the quality being such that the price was reduced from $1.31 to 96 cents per barrel about January 1, 1904. The Indiana Pipe Line Company has built a loading rack for tank cars and an 800-barrel storage tank on the Miller lease, west of Princeton. From this point lead pipes are put down to the producing wells as fast as finished. During the month of December, 1903, 992 barrels were shipped from the field.

While the area of productive territory about Princeton will doubtless be found to cover a number of square miles, the output of the field will never, in my opinion, be very large. The oil-producing sand is too thin and pockety to yield many big wells, and the output of those completed will rapidly diminish. The history of the field will, in all likelihood, be a repetition of that at Loogootee, where the conditions confronting the operator were practically the same.

* * *

Adding to the output of the Trenton rock petroleum fields, that produced by the Corniferous limestone at Terre Haute, and by the Huron sandstone at Loogootee and Princeton, we find the value and total production of petroleum in Indiana in 1903 to be as follows:

| | *Barrels.* | *Value.* |
|---|---|---|
| Trenton rock oil | 9,161,331 | $10,457,659 |
| Corniferous rock oil | 13,940 | 15,913 |
| Huron rock oil | 2,451 | 2,797 |
| Total | 9,177,722 | $10,476,369 |

As one travels through the oil district of the State a sense of the greatness of the industry grows rapidly upon him. One might study it for years and yet not master its every intricacy. He

finds a vast system of pumps, tubes and pipes drawing a stored liquid from the depths of the earth, and transporting it hundreds of miles to distant refineries, there to be separated into parts, each of which serves as a basis for articles of manifold kinds for the use of man. Depending upon this industry are several thousand men—rig-builders, drillers, tool dressers, pumpers, pipemen, gaugers, etc.; each class performing a special duty and all working in harmony for the advancement of the common industry. Yet the resource itself is seldom seen, except where it overflows in waste, even by the army of workmen who are engaged in its production.

In a study of such resources as coal, clay, building stone, etc., one can see the strata *in situ,* note their arrangement, measure their thickness and study in detail their relation to their surroundings; but in an area covered so deeply with drift as is the main oil field of Indiana, and where the resource in question is contained in a rock formation nowhere exposed to view within the State, the difficulties in the way of a proper presentation of the subject are many. The records of the formations passed through by the bores had to be obtained from drillers and operators, many of whom had little geological knowledge. Moreover, their records were scanty in detail, noting, as we have seen, little else than the number of feet of drive pipe and casing used, the depth at which the Trenton rock was found and the total depth of the bore. However, I found them at all times willing to place at my disposal such knowledge and records as they possessed, and to them I am indebted for such records as are included in the report.

To James McCormick, of Hartford City; Alex. McDonnell, of Montpelier; Albert Stevens, E. F. Aldrich and Geo. E. Scott, of Muncie; Chas. A. McLain, of Parker City; L. C. Davenport, W. H. Mandeville, C. M. Miller and W. A. Kunkle, of Bluffton; Benj. Fulton, of Portland; Jas. E. Hardison, of Geneva; B. A. Kinney, L. A. Von Berin, Fred Foreman, J. R. Bennett, Joshua Strange and R. J. Heald, of Marion; L. H. Legler, of Evansville, and Harry Kurtz, of Princeton, I am under special obligations for services rendered, both in the field and since my return therefrom.

# THE LIME INDUSTRY IN INDIANA.

By W. S. Blatchley.

Lime or quicklime has been manufactured and used in Indiana since the days of the pioneers. The first settlers with their rude log cabins, whose chimneys were formed of sticks and mud, of necessity did without it; but as soon as more substantial log and frame buildings with chimneys of stone or brick were erected, lime for mortar and plaster became necessary. At first rude kilns were constructed in each locality, where stone or marl could be readily secured, and in these lime was burned for neighborhood use. From these first crude stone or "ground-hog" kilns, erected on the side of a bluff or hill and operated by a single man, to the great plants of the present day, with their dozen or more large steel kilns and hundreds of workmen, is a notable advance—in keeping with a similar advance in other and kindred industries of the State. But little or nothing concerning the lime industry in Indiana has heretofore appeared in the reports of this Department. The present importance of that industry, due largely to the many and varied uses to which lime is now being put, is reason sufficient for the preparation of the present paper.

Calcium carbonate, or carbonate of lime, is one of the most abundant chemical compounds occurring in a natural state. Shells of oysters, clams, snails, and all other land and water mollusks are mainly composed of it, as are also those coral reefs which cover thousands of square miles of the ocean's floor. All the larger and purer beds of limestone which form a great portion of the surface or crust of the earth are also made up of carbonate of lime. They were formed of the framework and shells of mollusks, corals and other marine animals which existed in untold numbers in the seas, on whose floors or bottoms the sediment of the limestone was first deposited. Oölite, chalk, marble, travertine, tufa and calcareous marl are but names of other forms of carbonate of lime.

Calcium carbonate, when pure, is composed of one part of calcium (Ca) combined with one part of carbon (C) and three parts of oxygen ($O_3$), the chemical formula of the compound being $CaCO_3$. If this carbonate of lime be roasted or subjected to great heat it is split up into a gas and a new solid. $CaCO_3 = CO_2 + CaO$. The gas, carbon dioxide ($CO_2$), escapes and the solid, calcium oxide (CaO), is left behind as the unslacked lime or quicklime of commerce.

It is a common belief among masons, architects and others that the best lime is produced only from the purest carbonate of lime. Statements to that effect are also often found in text-books on chemistry. Experience has proven that such beliefs and statements are wholly erroneous. Some of the best lime in Indiana is made from stone containing a high percentage of magnesia. The Delphi and Huntington limes are burned from this magnesian limestone, analyses of which show the presence of 44 per cent. of magnesium carbonate as against 53 of calcium carbonate. When burned, the magnesium carbonate is reduced to magnesium oxide and the resulting lime is a mixture of magnesium and calcium oxides. These magnesium limes are preferred by many masons, as they claim that the mortar made from them is "cooler" and sets more slowly. Mortar made from pure lime is, in their language, too "hot" and "quick setting." It is also claimed that the magnesian limes have better cementing qualities.

Lime is a brittle, white, light gray or cream colored solid with a specific gravity of 2.3 to 3. It is one of the most infusible compounds known, withstanding the extreme heat of the oxyhydrogen blowpipe, but when exposed to it giving off a light of such exceeding brilliancy as to be almost unbearable to the eye. Lime has a very strong attraction or chemical affinity for water, uniting with it with such vigor as to generate great heat. This process is called slacking or slaking. When the freshly burned lime is exposed to the atmosphere for any length of time, this affinity for water causes it to absorb moisture, or "air-slack." It then crumbles into a white powder and loses much of its usefulness for certain purposes. A sample left in this office for a week and then analyzed was found to contain 8.5 per cent. of moisture which it had absorbed in that time. On account of this attraction for the mois-

ture of the air, lime is termed a perishable product, which should be used as soon as possible.

When water-slacked, pure lime swells very much and ultimately falls into a snow-white powder. Lime (CaO) + water ($H_2O$) = the calcium hydrate ($Ca(OH)_2$) of chemists; the latter being the white powder. If more water is then added, what is called the "milk of lime" is formed. This is composed of particles of calcium hydrate suspended in water. When this milk of lime is exposed to the air the extra water evaporates, and the calcium hydrate slowly absorbs carbon dioxide from the air and changes into calcium carbonate. Calcium hydrate ($Ca(OH)_2$) + carbon dioxide ($CO_2$) = calcium carbonate ($CaCO_3$) + water ($H_2O$).

## Uses of Lime.

The most important use of lime is in the production of mortar and plaster. For that purpose it has been used by all modern and most ancient civilized nations. In the earliest masonry of which any remains have been found, as the Etruscan, that of the Island of Cyprus and ancient Troy, walls were laid up with large stones without mortar ("cyclopean" masonry), or with smaller ones packed in clay; but by the Egyptians, Hebrews, Greeks and Romans, the use of lime for mortar was universal.

In the preparation of mortar, sand is added according to the richness or "fatness" of the lime—that is, according to the fineness and uniformity of the powder into which the lime falls when water-slacked. Where the resulting powder is very fine it makes with the water a milk of lime or lime paste which will penetrate the minute spaces between the grains of sand, however closely they may be crowded. The thinner the film of paste between the grains of sand, the stronger their adhesion will be in the future. Hence the value of a lime is roughly measured by the quantity of sand it will serve to unite—the better the lime, the greater the quantity of sand which it will bind together to form mortar or plaster.

As the lime in the mortar gradually hardens by absorbing carbon dioxide from the air, it also unites with the sand to form calcium silicate or silicate of lime. This is one of the important constituents of hydraulic cement and by its formation the strength of the mortar is still farther increased. The latter often continues

to absorb carbon dioxide and by its aid form calcium silicate for hundreds of thousands of years before being saturated. Hence the great tenacity of old mortar, that in the Egyptian pyramids being as hard as the stone it joins together. Chemical analyses clearly prove that in these old mortars the silicate of lime is much greater in quantity than in those more recently made.

The great increase in recent years in the number of brick and stone buildings, due largely to the disappearance of our forests and a consequent rapid advancement in the price of lumber, has led to a greatly increased demand for lime for mortar making. Probably 70 per cent. of that produced in Indiana is used for this purpose alone.

Whitewash, much used instead of paint as a surface covering for outbuildings and fences in the country, and also as a purifier and disinfectant, is simply "milk of lime" mixed with a little glue. Much lime is also used in making "bleaching powder" or chloride of lime. This is formed by passing chloride gas into leaden chambers containing slacked lime which absorbs the gas very rapidly. Chloride of lime is a dry white powder which smells faintly of chlorine and has a strong taste. It dissolves partially in water and the solution is much used for bleaching cotton goods.

Lime acts on the skin like a caustic alkali and is therefore used by tanners for removing hair from hides and by glue manufacturers in the making of glue from scraps of hides and hoofs. It is also necessary in the manufacture of caustic soda and caustic potash, and large quantities are used for this purpose. These caustic alkalies are much used in soap manufacture, so that the soap industry depends indirectly upon that of lime making.

Lime is also extensively used in glass making, and as a flux in smelting iron. It is customary, however, to use finely ground limestone for glass manufacture and chunks of pure limestone in blast furnaces. During the melting of the glass ingredients or the smelting of the iron ores the limestone gives up its carbon dioxide and is changed into quicklime, the latter serving as the fluxing agent in both cases.

Large quantities of lime are also used in paper manufacture, especially in strawboard works. Pure lime to the amount of 1,500 or more pounds, is first placed in a large rotary and steam turned in until it is thoroughly slacked. The hot slacked lime is then

blown into another rotary containing the straw which it bleaches and aids in reducing to a pulp. In the making of paper from rags, milk of lime and water are added to a rotary boiler which is filled with rags. The boiler is then slowly revolved, steam being admitted under pressure. This cooking thoroughly softens the grease or any dirt remaining in the rags, at the same time rendering them more easily reduced to paper pulp.

The making of a "sand brick" from sand and lime has lately come into vogue and promises to cause a demand for quite a quantity of lime in the near future. Three large factories are already in operation in Indiana and several others will soon be erected. In the making of these brick from eight to twelve per cent. of unslacked lime is used. This is ground fine and mixed intimately with the proper amount of clean, pure sand, and the mixture is then put through a pressed brick machine. The brick as they issue from the machine are piled on iron cars and wheeled into large air-tight steel cylinders, which, when full, are closed and sealed. The brick are then subjected to a high steam pressure for 12 to 15 hours, when they are ready for the market. They are of a white or cream color, and are used the same as ordinary brick for building purposes. Some care must at first be taken in handling and laying them, but they soon harden and in time become more firm and solid than the ordinary kiln-burned clay brick. The reason for this gradual hardening is the same as for that of mortar, viz., the combining of the slacked lime with a portion of the silica of the sand to form a calcium silicate which, in time, binds or cements the particles of sand firmly together. Where the right kind of sand is plentiful and lime can be had for a reasonable price, sand brick can be made very cheaply, as there is a great saving in time and in the amount of fuel required for their manufacture.

Much lime is used either as a fertilizer for soils or as a means of improving the mechanical condition of soils. It can only be used as a fertilizer with profit where the soil is lacking in calcium, as that is the only element of plant food which lime contains. Most soils contain lime enough for practical use, as a lime content of one per cent. in a soil is always sufficient. When the amount falls below one per cent. the application of lime fertilizers is occasionally beneficial, and always so when only one-quarter to

one-half per cent. of lime is present. When less than one-quarter of one per cent. of lime is found in the soil, liming is absolutely necessary. Caustic lime or quicklime is the most concentrated form of lime which can be applied as a fertilizer. The finer the state of division it is in when applied the quicker and more direct will be the benefits derived. The hydrated lime manufactured at Milltown, Indiana, especial mention of which will be made on a subsequent page, is for this reason extensively used as a top-dressing for soils.

The use of lime "as a means of improving the mechanical condition of soils" is a very important one, and is worthy of more general practice than it has received from farmers in the past. A soil may contain all the elements or ingredients necessary for the production of a certain crop and yet, on account of its mechanical condition, its extreme looseness or porosity, or its compactness, plants can not grow in it. By the application of certain materials, one of the best of which is quicklime, these unfavorable physical properties of the soil are often modified or broken up, so that the plants can avail themselves of the store of fertility in the soil, and a good crop is the result.

Many clay soils, when wet by rains, are not porous enough to allow the water to pass through them with sufficient rapidity. As a consequence they become water-logged and the air which is necessary for the healthy growth of the plant roots is excluded. In time of drought such soils cake readily, thus forming large clods, and becoming more difficult to till and less adapted to the sustenance of the growing plant. Some compound of lime, when applied in sufficient quantity, will prevent this puddling or caking, thus allowing the water, air and heat to thoroughly permeate the soil. The texture of the soil will also become more suitable for the easy penetration of the roots and rootlets of the plants.

## Lime Making Materials in Indiana.

Indiana is rich in materials suitable for the making of lime. Moreover, they are widely scattered throughout the State. In the southern part the Mitchell and Bedford limestones furnish an abundance of the purest carbonate of lime. In the northern part

the Niagara limestone in its outcrops along the valley of the Wabash and its tributaries, has long been the source of a fine grade of magnesian limestone which is noted for the excellence of its lime product. The marl deposits scattered about the lakes and marshes of the northern third of the State, furnish also a good lime-making material which was once quite extensively utilized for that purpose, and could be again if necessity required.

THE MITCHELL LIMESTONE.—This is one of the Lower Carboniferous limestones, which immediately overlies the Bedford limestone and forms the surface rocks in an area three to 25 miles in width in an irregular strip extending from the Ohio River northward to near Crawfordsville, Montgomery County, where it disappears beneath the drift. The area covered by the Mitchell limestone thus embraces parts of the following counties: Harrison, Crawford, Floyd, Washington, Orange, Martin, Lawrence, Monroe, Owen, Morgan, Putnam and Montgomery. In this area the Mitchell limestone has been utilized for making lime on an extensive scale at Milltown, Mitchell, Limedale and Okalla; while at numerous places throughout the area isolated kilns are or have been in operation for burning lime for local use.

The Mitchell limestone varies much in structural character and appearance. In most places it is a fine-grained, crystalline or sub-crystalline stone which is quite hard. In the southern part of its area there are found in a number of localities near the top of the Mitchell and between the beds of grayish stone, layers having an oölitic structure, nearly pure white in color and much softer than the gray. This "oölite" outcrops at Milltown, Marengo, and numerous other localities in Crawford County; at the Stockslager quarry in Harrison County; in Madison and Posey townships, Washington County, and at numerous places along the French Lick Branch of the Monon Railway west of Paoli, in Orange County. Both it and the more common gray Mitchell limestone comprise the purest forms of carbonate of lime found in the State.

The following table of analyses shows the composition of the Mitchell limestone from four widely separated localities;

ANALYSES OF MITCHELL LIMESTONE FROM SOUTHERN INDIANA.

| Source of Sample. | Calcium Carbonate ($CaCO_3$). | Magnesium Carbonate ($MgCO_3$). | Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$). | Insoluble Residue (Silica, etc.). | Total. | Authority. |
|---|---|---|---|---|---|---|
| Oölite from Eichel Quarry, Milltown, Ind | 98.91 | .63 | .15 | .48 | 100.17 | W. A. Noyes. |
| Gray stone from Mitchell Lime Quarry, Mitchell, Ind | 96.65 | 1.20 | .27 | 1.57 | 99.69 | —— —— |
| Gray stone from South of Harrodsburg, Ind | 97.64 | ..... | .32 | .82 | 98.74 | T. W. Smith. |
| Gray stone from land of J. B. Lyne, Monroe County | 99.04 | ..... | .09 | .80 | 99.92 | T. W. Smith. |

The last analysis given is from a ledge of the gray Mitchell limestone on the land of J. B. Lyne, in the southeast quarter of section 32 (8 N., 1 W.), five miles south of Bloomington, Indiana. This showed the highest per cent. of carbonate of lime of any Indiana stone whose analysis has been seen by the writer.

The above analyses show that the Mitchell limestone is a remarkably pure carbonate of lime, in every way suitable for making the purest of quicklime, not only for mortar-making purposes but for chemical and other uses where great purity of the raw ingredient is necessary. Farther analyses of the Mitchell stone will be given in connection with the descriptions of the plants now making lime from it in southern Indiana.

The Bedford Oölitic Limestone.—This is the best known limestone in the State, being the formation so extensively quarried for building and ornamental purposes. It is one of the Lower Carboniferous limestones, and forms a portion of the surface rocks in a narrow irregular strip from two to 14 miles in width, extending a distance of 110 miles from near Greencastle, Putnam County, to the Ohio River. Its outcrops occur in Putnam, Owen, Monroe, Lawrence, Washington, Floyd and Harrison counties. Numerous quarries have been opened throughout this area for building stone, and lime has been burned at a number of points, but nowhere on as extensive a scale as at Mitchell and Milltown, where the Mitchell limestone is used. The Bedford oölitic stone ranges from a creamy white to a dark drab in color. It is very

uniform in grain and quite soft when first quarried. Under the microscope it is seen to be made up of the globular shells of minute one-celled animals. These are composed of carbonate of lime and are cemented together by the same material, so that the rock is a very pure limestone, ranking close to the Mitchell stone in chemical composition. From a number of analyses of the Bedford stone made by Dr. Noyes for the Twenty-first (1896) Report of this Department the following are taken to show its composition:

ANALYSES OF BEDFORD OÖLITIC LIMESTONE FROM SOUTHERN INDIANA.

| Source of Sample. | Calcium Carbonate ($CaCO_3$). | Magnesium Carbonate ($MgCO_3$). | Ferric Oxide ($Fe_2O_3$). | Insoluble Residue (Silica, etc.). | Total. |
|---|---|---|---|---|---|
| Bedford, Indiana, Stone Quarry, Lawrence County | 98.27 | .84 | .15 | .64 | 99.90 |
| Hunter Bros. Quarry, Monroe County..... | 98.11 | .92 | .16 | .86 | 100.05 |
| Romona Oölitic Stone Company, Owen County ..... | 97.90 | .65 | .18 | 1.26 | 99.99 |
| Twin Creek Stone Company, Washington County .. | 98.16 | .97 | .15 | .76 | 100.04 |

The average of eight analyses of specimens from eight of the leading quarries of Bedford stone showed the following percentage composition: Calcium carbonate, 97.62; magnesium carbonate, .61; iron oxide and alumina, .36; insoluble residue, .91. These analyses show the fitness of the Bedford oölitic stone for making a very pure quicklime; and the practical burning of the lime at Salem, Bedford and other points proves that fitness. For some reason, however, the lime industry in the oölitic stone district is not as flourishing as it should be. Abandoned kilns are found in a number of localities in the area, notably in Monroe County, near the old University building at Bloomington, and at Ellettsville; in Lawrence County, two southwest of Bedford, and three south of the same place along the Monon Railway, and in Owen County at Romona. Prof. T. C. Hopkins, in a chapter on "The Commercial Features of the Bedford Oölitic Limestone," comments on the lack of use of the Bedford stone for lime making, and gives, doubtless, the real reasons for the neglect of the industry in the area. I quote from him as follows:*

*21st Ann. Rep. Ind. Dept. Geol. and Nat. Res., 1896, p. 337.

"To see the great quantity of waste rock on the dump piles about the oölitic quarries one wonders why more of it is not burnt into lime, and no satisfaction could be obtained to that query when put to the quarrymen. One said it did not make good lime. Another that the lime was too hot, and some had not thought of it, did not know it had ever been tried, or would make lime at all. One only needs to look at the table of analyses of the stone to see that it would make a fat or rich lime, but that should not be a serious objection, as for many purposes a rich lime is preferred to any other. The reason that more of it has not been burnt may be due to a number of causes: 1. Freight rates, the cost of bringing in the coal and shipping the lime. 2. A prejudice in the local markets against rich lime. 3. Want of a large market, as the quarries are situated in the midst of the Mississippi Valley, with large deposits of limestone on all sides. 4. The lack of some enterprising person to push the business into prominence, as all the stone dealers are interested in the sale of building stone and not lime. The last is probably the most important reason."

THE NIAGARA LIMESTONE.—This limestone is the principal formation representing the Upper Silurian Period in Indiana. It forms the surface rocks over a wide area of the eastern and northern portions of the State and also over an irregular narrowing strip, 30 miles to one in width, extending southward from Newcastle, Henry County, through portions of Wayne, Rush, Fayette, Franklin, Decatur, Ripley, Jennings, Jefferson and Clark counties to the Ohio River near Jeffersonville. Through this narrow strip the rock is close to the surface, but in the larger area north of Newcastle it is nearly everywhere covered with deep drift. However, in the valley of the Whitewater and its tributaries in northern Wayne County, at Portland, Jay County, and along t
Wabash River in the vicinity of Bluffton, Huntington, W
and Logansport it comes to the surface, as also in isol
near Delphi, Monon and Kentland. At a number o
ties and also near Utica, Clark County, the N
years been burned into a high grade of l
that at nearly every point where it outcrop
able for lime making.

The Niagara limestone ranges from nearly whi
to blue in color and from a hard, suberystalline ston

shaly one in structure. In Decatur, Franklin and Wabash counties it is, in places, especially hard and compact, of even texture and color, and often occurs in thin, easily separated layers, usually from three to 12 inches thick which are largely quarried for flagging, curbing and similar uses. In other places it is known as "cliff rock" owing to the fact that the thick, uppermost layers withstand the action of the weather and form steep cliffs and bluffs along the ravines and lines of outcrop.

The chemical composition of the Niagara limestone varies greatly. In southern Indiana it usually contains only from 6 to 10 per cent. of magnesium carbonate, but the outcrops along the Wabash River contain 40 per cent. or more of this compound. This is especially true of certain outcrops in the vicinity of Huntington, Wabash and Delphi, where the Niagara stone seems to have passed through an upheaval, the strata being tilted in various directions, sometimes at an angle of 45 degrees or more. Near Delphi, Monon, and Kentland, Newton County, the Niagara comes to the surface in isolated islands in which the layers show this same tilted condition. Dr. E. M. Kindle has studied carefully the outcrops and stratigraphy of the Niagara through this region and has an interesting paper concerning it on subsequent pages of the present volume. The following table shows the variability of the Indiana Niagara limestone in chemical composition:

ANALYSES OF INDIANA NIAGARA LIMESTONE.

| Source of Sample. | Calcium Carbonate ($CaCO_3$) | Magnesium Carbonate ($MgCO_3$) | Ferric Oxide and Alumina ($Fe_2O_3+Al_2O_3$) | Insoluble Residue (Silica, etc.) | Sulphuric Anhydride. | Total. | Authority. |
|---|---|---|---|---|---|---|---|
| Consolidated Lime Company, Huntington | 53.22 | 44.96 | .23 | .59 | .11 | 99.11 | R. E. Lyons. |
| Harley Bros. Quarry, Delphi, Carroll Co. | 54.53 | 43 92 | .51 | .19 | .18 | 99.33 | R. E. Lyons. |
| Greensburg Stone Company, St. Paul, Decatur Co | 74.02 | 10.35 | 6.20 | 5.90 | .90 | 97.37 | E. T. Cox. |
| Scanlan's Quarry, Flat Rock Creek, Decatur Co | 83.00 | 6.3 | 2.50 | 5.30 | 1.00 | 98.10 | E. T. Cox. |

The limestones from Huntington and Delphi, whose analyses are given, have long been used in making the magnesian limes for

which those two points are famous. These limes are "cooler" or more "slow-setting" than those from the purer Mitchell and Bedford limestones and for that reason are preferred by many masons and builders. There is little doubt but that as good lime can be made from the Niagara stone at a number of other points along its outcropping horizon in Huntington, Wabash, Miami and Cass counties as at Huntington and Delphi. While analyses are not available, it is believed that the stone at Monon and near Kentland will also make a good grade of lime. The analyses of the Niagara stone in the southern part of its area show that a lime intermediate in character between that made at Delphi and Huntington, and that from Mitchell and Milltown could be produced. Large quantities are at present burned at New Paris, Preble County, Ohio, but six miles east of Richmond, Wayne County, Indiana, and for years kilns were in operation at Cox's Mills, five miles northeast of Richmond, and near Laurel, Franklin County. At these localities the Niagara limestone, similar to that at Decatur and St. Paul is or has been in use. A fine grade of lime has also been manufactured for years from a gray, crystalline, Niagara limestone in the vicinity of Utica, Clark County. Prof. W. W. Borden, in 1873, wrote of the industry in this vicinity as follows:* "The lime burned and sold under the name of the Utica lime has acquired by long use a high reputation, and where known is used in preference to all other brands. J. Speed, Esq., has erected at Utica two of Page's patent kilns, each producing 120 barrels of lime per day. At Robinson's landing, a few miles above Utica, Mr. Jacob Robinson burns of the same stone ten thousand barrels per year. The fuel employed is wood and requires four cords to burn one kiln. The Utica Lime Company use a mixture of wood and coal, and have two kilns, each producing 90 barrels of well burned lime per day. The Louisville Cement and Lime Company, and the Utica Lime Company, and Mr. J. Robinson burn 125,000 barrels of lime per year, employing in the business a large number of hands."

On account of a lack of proper transportation facilities at Utica, where shipment is possible only by boat on the Ohio River, the industry has gradually dwindled to about 8,000 barrels per year.

*5th Ann. Rep. Geol. Surv. of Ind., 1873, p. 145.

MARL AS A SOURCE OF LIME.—About the existing lakes, and the extinct lakes and marshes of the northern third of Indiana are many extensive deposits of marl or "merl" as it is called in the country. This marl is a soft, earthy material, composed principally of an amorphous form of carbonate of lime. Its color varies with the percentage of impurities which it contains, from a milky white to a dark brown when wet; and from a white or cream to a slate color when dry. The grains or particles composing the dry mass cohere very slightly and vary in size from coarsely granular to fine powder. They effervesce very freely and in time wholly disappear in cold muriatic acid, which is the principal test for carbonate of lime. These marls were deposited in the still waters of the lakes of the region, the original source of the marl material being the glacial clay and rock flour which formed a large part of the till or drift of the region surrounding the lakes. Percolating through the deposits of glacial clays and limestone debris, rainwater has, for centuries, dissolved and become saturated with the carbonate of lime. It has then flowed onward underground until it issues forth in the form of a spring, either bubbling up from the bottom or flowing in from the side of the basin in which the lake is located. In the warmer waters of the lake, the carbonate of lime has then been deposited until it has formed the vast beds of so-called marl.*

Several hundred deposits of marl occur in the lake region of the northern part of the State. These vary in size from an area a rod or two square and a foot or two deep, up to hundreds of acres, twenty or thirty feet or even more in depth. In the report cited, are full descriptions of thirty-two deposits which contain a body of marl equal to 160 acres in area and ten feet thick. The following are analyses of average samples of marl from five of these deposits, made by Dr. W. A. Noyes for the 1900 Report. From them one can judge as to the chemical composition of the average deposit in the State:

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*For a full account of the Lakes of Indiana and their accompanying marl deposits, as well as for detailed information regarding the formation, deposition, properties and uses of marl, see the paper by Blatchley and Ashley, in the 25th (1900) Report of this Department, pp. 31-321.

## ANALYSES OF INDIANA MARLS.

| Origin of Sample. | Calcium Carbonate ($CaCO_3$) | Magnesium Carbonate ($MgCO_3$) | Ferric Oxide and Alumina ($Fe_2O_3 + Al_2O_3$) | Insoluble residue (silica, etc.) | Organic matter. | Total. |
|---|---|---|---|---|---|---|
| Lake James, Steuben Co | 92.41 | 2.38 | .29 | 1.16 | 1.97 | 98.36 |
| Tippecanoe Lake, Kosciusko Co | 90.67 | 2.42 | .32 | 2.48 | 2.87 | 98.76 |
| Manitou Lake, Fulton Co | 87.65 | 2.60 | .49 | 6.39 | 2.88 | 100.01 |
| Maxinkuckee Lake, Marshall Co | 85.38 | 3.50 | .38 | 6.40 | 3.15 | 98 98 |
| Chain and Bass Lakes, St. Joseph Co | 87.92 | 2.64 | .30 | 3.10 | 4.18 | 98.37 |

In the early settlement of northern Indiana much quicklime was made from these deposits of marl. No one of the counties in which the principal deposits occur has outcrops of limestone, and hence the marl was used, being burned in rude kilns erected for the purpose. Richard Owen, in his report on St. Joseph County, says: "Beneath the swamp-muck beds in the Kankakee marshes near South Bend, a shell marl, three to ten feet thick, is obtained. At many places this is dug and moulded into brick-shaped masses of considerable size, so as to be readily piled in a kiln, burnt and used for all purposes to which lime is usually applied, being of an excellent quality and white color. An extensive manufacture of this kind is also carried on near the fine Catholic College of Notre Dame, beautifully situated a mile or two north of South Bend."*

Other localities where the marl lime was made, were near Rochester, Fulton County; Lime Lake, Steuben County; Albion, Noble County, and Silver Lake, Steuben County. The lime from the marl was snow-white in color, and very perishable owing to its fine mechanical condition. As much of the mortar made from the burned marl did not endure exposure to the weather (probably on account of too small an amount of sand being used in its composition), the use of marl as a lime material was discontinued when railways were constructed which brought in from Wabash, Delphi and Huntington a superior lime. The manufacture of quicklime from the marl for use in mortar will, however, probably never be renewed, as the quality of the lime produced at the lime burning

*Report of a Geological Reconnaissance of Indiana, 1859, p. 200.

cities along the Wabash, taken in connection with the present cheap and rapid means of transportation, will not justify its renewal.

## The Burning of Lime.

As has been stated, quicklime is produced from limestone by calcining or roasting the latter. In this process the carbon dioxide gas is expelled, and the solid quicklime of commerce remains. This burning, roasting or calcining is effected in kilns of various kinds. The kilns used at local points for burning lime for neighborhood use are or were intermittent kilns of stone. In them the fire was allowed to go out after each burning, to be started again after the kiln was recharged with stone. These cheaper, temporary or "ground-hog" kilns were rudely constructed of stone,

Fig. 1. Old-fashioned "ground-hog" or temporary lime-kiln.

and were located on the side of a hill, so that the top was easily accessible for charging the kiln with stone, and the bottom for supplying fuel and drawing out the lime. In charging, the largest pieces of limestone were first selected and formed into a rough, dome-like arch with large open joints springing from the bottom of the kiln to a height of five or six feet. Above this arch the kiln was filled with fragments of limestone from the top, the larger

pieces being used in the lower layers, these being topped off with those that were smaller. A fire of wood was then started under the dome, the heat being raised gradually to the required degree in order to prevent a sudden expansion and consequent rupture of the stone forming the dome. Should this happen, a downfall of the entire mass above would take place, thus putting out the fire and causing a total loss of the contents of the kiln. After a bright heat was once reached through the mass of stone, it was maintained for three or four days to the end of the burning. This was indicated by a large shrinkage in the volume of the contents, the choking up of the spaces between the fragments and the ease with which an iron rod could be forced down from the top. The fire was then allowed to die out and the lime was gradually removed from the bottom. It was in this manner that all the lime used in Indiana for many years was burned, and in some localities these temporary intermittent kilns are still in operation. The process of burning is simple and cheap, the only expense being for blasting the stone and preparing the fuel. Possibly but one or two kilns were necessary to supply a neighborhood for a year. These were burned in a week or two when required, the kiln remaining idle for the remainder of the time.

As the population increased, the demand for lime became greater, and in many places permanent kilns lined with fire brick were erected. These were the old fashioned stone "pot kilns" of a quarter of a century ago. On the inside they were usually circular in horizontal section, tapering slightly, by a curve both up and down from the circle of largest diameter, which was from four to six feet above the bottom. A kiln 10 to 11 feet in greatest diameter, was 25 to 28 feet high, five to six feet in diameter at the top and seven to eight feet at the bottom. There was an arched opening on one side at the bottom, five to six feet high, through which the wood was introduced and the burnt lime removed. A horizontal grating on which the fire was built was usually placed one or two feet above the bottom. In all these intermittent kilns there was an enormous loss of heat at each burning, for the quantity of fuel, necessary to raise the contents of the kiln and the thick stone and brick walls to the degree of heat necessary to form the lime, had to be repeated each time the kiln was charged. Moreover, the

stone nearest the dome-arch in the kiln was liable to become injured by over-burning before the top portions were thoroughly calcined.

As wood became scarcer and the demand for lime increased, these intermittent kilns gave way to continuous or perpetual burning kilns, usually of stone, in which the lime was burned by coal without intermission in the fires. In the first styles of these, some of which are still in use, the kiln was filled with alternate layers of coal and limestone and then fired from below with light wood. As the burning was completed in the lower portion of the kiln the finished lime was drawn out from time to time, usually twice each 24 hours, allowing the entire mass above to settle down. New layers of fuel and stone were then added at the top.

These old style perpetual kilns have mostly been replaced by cylindrical steel kilns, 35 to 40 feet in height and six to eight feet in inside diameter. These kilns have two (sometimes four) furnaces, one on either side, situated at about one-third of the height from the bottom. In these the fires are kept perpetually burning, wood, coal, oil or gas being used as fuel. The limestone is elevated in steel cars by means of a tramway to the tops of the kilns and dumped into them until they are full. The flame and heat from the fires in the furnaces pass up through the limestone and thoroughly roast it, so that by the time it has descended to near the level of the furnaces, it has been deprived of all its carbon dioxide gas and converted into lime. The latter is then drawn out at the bottom, the drawing taking place about once every six hours. The limestone for burning should be broken into pieces not exceeding four to six inches in diameter, else the inside of them is liable to remain unburned. More or less trouble is experienced at all kilns with these "cores" or unburned centers, as the pieces of lime containing them have to be sorted from the shipment.

The steel perpetual kilns are a great improvement over the old stone ones in which the coal was mixed with the fuel, as the resulting lime is cheaper and purer, and much less fuel is necessary. All modern lime-making plants are equipped with them, most of those in Indiana being of the Monitor pattern, costing about $1,500 each.

# THE MANUFACTURE OF LIME IN INDIANA.

## At Delphi, Carroll County.

Delphi, the county seat of Carroll County, is a city of 2,500 population, located at the junction of the C. I. & L. (Monon) and Wabash railways, 72 miles northwest of Indianapolis and 112 miles southeast of Chicago. The city is picturesquely located on the high banks of Deer Creek, near the junction of that stream and the Wabash River.

The lime industry in the vicinity of Delphi has been an important one for many years; the "Delphi lime" having a wide reputation for the excellence of its quality. The first kilns, as in other localities, were of a very crude, temporary nature, in which only lime sufficient was burned to supply the local demand. However, the quality of the lime began to attract attention in other places and in 1858 the firm of E. W. Hubbard & Co., composed of E. W. Hubbard, E. R. Harley and Robert Mitchell, was organized for burning lime for shipment. Their principal outlet was along the old Wabash and Erie Canal, as long as that waterway was in operation. The larger part of the output was shipped to Covington, Ind., and from there hauled in wagons to points in Illinois and western Indiana. The old-fashioned intermittent stone "pot kilns" were used until 1870. These held from 1,000 to 1,200 bushels of lime. They were filled one day, burned two and a half to three days, and emptied in a day or two. There was much waste of fuel, due to the necessary cooling at the end of each burning. About 20 of these kilns were operated by the company.

By 1870 several other firms had started in the business. In that year there was a combination of all of these and the pioneer company under the name of "The Delphi Lime Company." The old stone intermittent "pot kilns" were soon replaced by more modern steel ones in which the burning was continuous. The old company operated the plant until 1891, when it was sold to a Mr. Cartwright, who controlled it until 1902. For a year after his death the plant was closed, but a new company was organized under the old name, and the plant was again opened in September, 1903.

PLATE III.

KILNS OF DELPHI LIME CO., DELPHI, IND.

QUARRY OF DELPHI LIME CO., DELPHI, IND

THE DELPHI LIME COMPANY.—The present location of the Delphi Lime Company's kilns is about one mile north of the city limits of Delphi. No railway switch is connected with their plant, the lime being hauled in wagons to the city and there loaded on cars. The company owns twenty acres of limestone land, about half of which has been quarried out to a depth of 15 to 25 feet. In one place a pond, whose water is 12 to 15 feet in depth, fills an abandoned quarry several acres in area. The stone used is of the same character and quality as that burned by the other lime companies at Delphi, being a Niagara limestone, rich in magnesia. It is part of an island or uplift of rock, which was forced above the sea toward the close of the Niagara period. This island is remote from outcrops of the main body of Niagara limestone in the State, and forms the surface of an area of about 600 acres north and northwest of Delphi. As in other isolated deposits of Niagara in this portion of the State, the strata are much tilted, the main dip being 20° to 30° towards the northeast. The stone is, in places, very much shattered, and presents other evidences of a true upheaval.*

The kilns of the Delphi Lime Company are of the Monitor pattern and four in number, one large one being eight feet, the others six feet, in inside diameter. But one of these was in operation at the time of my visit, October 3, 1903. These kilns were among the first of their kind erected in the State, and differ from most others in having at the base four arches or furnaces instead of two. These are about ten feet above the bottoms of the coolers or pits to which the lime passes when thoroughly burned. Each of the smaller kilns produces about 200 bushels and the larger one 240 bushels of lime in 24 hours. Wood, costing $2.50 per cord, was being used for fuel, but on account of its scarcity it will soon be changed to coal. The superintendent claims that with wood, a fourth more lime can be gotten from the same amount of stone, than with coal, and that it can be burned in less time. The trade of the Delphi Lime Company had been largely lost by their year's shutdown, but it was hoped that it would soon be regained. The lime produced is similar to that of the Harley Bros. Lime Company, described later, brings the same price and is sold mainly for builders' use and for paper manufacture.

*See the paper by E. M. Kindle in another part of the present volume for further information concerning these "islands" of Niagara stone.

HARLEY BROS. LIME COMPANY.—The Harley Bros. Lime Company, composed of C. and G. P. Harley, began the burning of lime at Delphi in 1875. Their first kilns were located on a small tract of Niagara limestone land near the northern limits of the present city, but in 1891, having secured possession of a larger tract of stone land, they moved to their present location, one-eighth of a mile farther north. A switch from the Monon Railway runs to their plant. About $10,000 is invested, exclusive of the stone land, and their output of lime is the largest of the three plants located at Delphi. The three kilns operated by the company are of stone and are seven feet in inside diameter, with an output of 225 bushels each per day. The burning is by the continuous process, coal and a small amount of wood being used as fuel. The plant is operated the entire year, with the exception of a few weeks of the coldest weather—May, September and October being the months in which there is greatest demand for the product. In these months 35 men are employed in quarrying stone and operating the plant. Ordinary laborers and quarrymen receive from $1.50 to $1.60 per day; while burners, of which there are two to each kiln, receive $12.25 each for seven days' work.

Harley Bros. own 40 acres of stone land suitable for the burning of lime, their quarry being located just north of the kilns. From 12 to 18 inches of stripping is removed and the stone is then used to a depth of 16 feet. When exposed, the stone in many places is found to be very much broken, the fragments being often raised up in small dome-like arches. The appearance of one of these, in the words of one of the owners, is like that of a pot of hot mush which has been suddenly cooled off. Where layers of any area are found in this particular quarry, they dip 10° to 15° to the southeast. An analysis of this stone, made by Prof. R. E. Lyons for this paper, shows its composition to be as follows:

ANALYSIS OF STONE FROM HARLEY BROS.' QUARRY, DELPHI, IND.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 54.53 |
| Magnesium carbonate ($MgCO_3$) | 43.92 |
| Ferric oxide and alumina ($Fe_2O_3$+$Al_2O_3$) | .51 |
| Insoluble residue (silica) | 0.19 |
| Sulphuric anhydride ($SO_4$) | .18 |
| Total | 99.33 |

PLATE IV.

HARLEY BROS. QUARRY, DELPHI, IND.

HARLEY BROS. KILNS, DELPHI, IND.

The analysis shows the stone to be very rich in magnesia. The sum of the magnesium and calcium carbonates, both of which go to form lime, is 98.45 per cent., so that the amount of impurities is very small.

When blasted and broken to the proper size, the stone is loaded into steel cars holding one and a quarter yards, and hauled up a tramway to a point above the kilns where, by an ingenious arrangement, the cars are automatically dumped. A load of stone, so dumped, is converted into lime in about 36 hours. From 50 to 60 bushels of lime are drawn from the bottom of each kiln every six hours.

The Delphi lime, when fresh, is of a dirty brownish color, but when slacked bleaches out as white as any other. It is a "cool" lime which sets slowly. For this reason a much larger amount can be strewn with the trowel along a row of brick; whereas with a "hot" lime but enough can be scattered to lay three or four brick before it begins to set. It is on account of this property that it is so highly esteemed by masons. It is also claimed for it that it has better cementing qualities than a "hot" lime, requiring more sand to form a perfect combination and forming in time a very hard mortar joint. For paper manufacture Delphi lime is said to be superior to a pure calcium lime, as it does not clog the cloth or "felt" as rapidly as does the purer lime, hence the labor of cleaning the "felt" is lessened.

An analysis of the lime burned by Harley Bros. was made for the firm by Dr. J. N. Hurty, of Indianapolis, who reported its composition to be as follows:

ANALYSIS OF HARLEY BROS.' DELPHI LIME.

| | |
|---|---|
| Calcium oxide | 38.59 |
| Magnesium oxide | 31.76 |
| Clay | 26.63 |
| Silica | .14 |
| Loss | 2.88 |
| Total | 100.00 |

In October, 1903, the Delphi lime was bringing 13 cents per bushel of 70 pounds, or 60 cents per barrel, in car load lots, f. o. b. at Delphi. An ordinary car holds 550 bushels. The cost of man-

ufacture is said to be about 7½ cents per bushel. That made by Harley Bros. is sold mainly for building purposes, though quite a quantity goes to paper factories. The most of it is used in Indiana and northern Illinois. About ten per cent. is shipped in barrels, the remainder in bulk. On account of the great increase, in recent years, in the cost of barrel making materials, most lime manufacturers are trying to reduce the barrel shipments to a minimum. Each lime plant of any size has its own cooper shop. The cost of a barrel at the Delphi plants, in October, 1903, ranged from 23 to 26 cents, of which amount four or five cents went to the cooper, the rest for material. Indiana bituminous "mine run" coal is used for fuel and was being laid down at the plants for $2.40 to $2.70 per ton. Care must be taken to secure a coal as free from sulphur as possible, else a brownish crust will be formed on the lime during burning which will prevent it from properly water slacking.

THE COBLE LIME COMPANY.—In 1902 a number of Delphi and Frankfort citizens organized a new company for the purpose of burning lime at Delphi, and incorporated under the name of the Coble Lime Co. During the first year they burnt quite a quantity of lime in old-fashioned pot kilns, but in the spring of 1903, an up-to-date plant was erected at a cost of $12,000, about one mile north and a little east of the courthouse, and about half way between the two plants already described. Here the company owns 22½ acres of excellent stone land, which cost them $7,500. Four steel kilns were erected, each having a capacity of about 200 bushels daily. The kilns are a little smaller than the average, in order to burn the lime thoroughly with coal. A 20-horsepower gasoline engine furnishes power for hoisting stone and compressing air for drilling in the quarry. The kilns are filled twice each day, and the lime is drawn at intervals of six hours. Eighteen men were employed at the time of my visit, the average wages paid being $1.50 per day. The company had found a ready market for all the lime burned since June 5th, when the plant was first opened for business.

In the quarry just north of the kilns the stone is in places broken and upheaved, as in the other quarries in the vicinity. The dip of the strata in place is to the north. The lime produced is similar in appearance and quality to that made by Harley Bros. An

QUARRY OF COBLE LIME CO., DELPHI, IND.

KILNS AND STOREHOUSE OF COBLE LIME CO., DELPHI, IND.

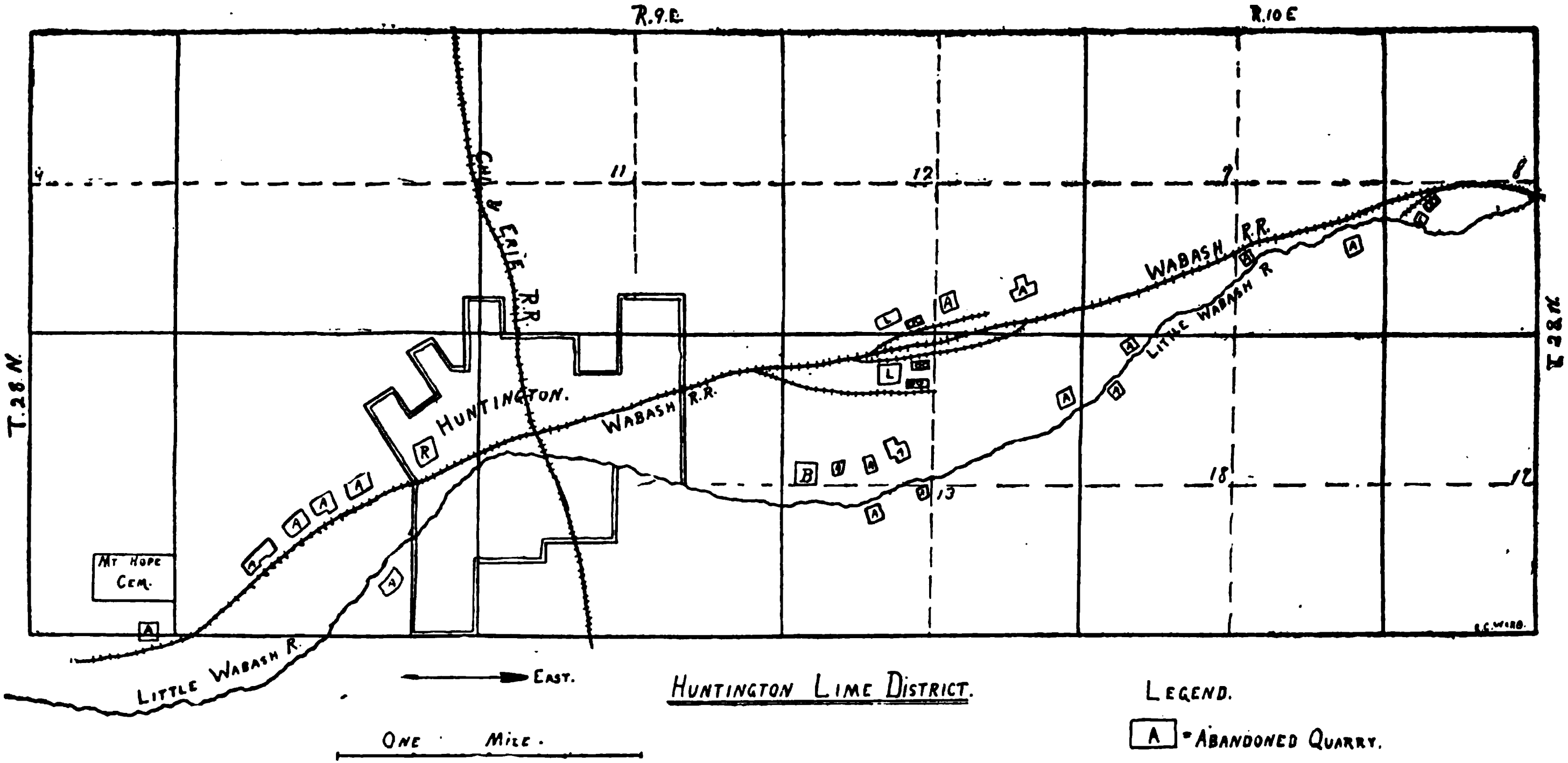
No. 2. Plant of Western Lime Co., Huntington, Ind.

and has eight kilns, six of steel and two of stone. It has not been operated for several years. One reason given for its closing was that the thick ledge near the top of the quarry from which stone was obtained was not so good as the underlying ledges, being shelly and fossiliferous. A mixed grade of lime was the result unless the stone was sorted. Another reason was that the output of the other three plants nearer town equaled the demand, and in closing one of the plants the one farthest distant was selected.

The active plants are equipped with 24 steel kilns, 20 of which were burning lime on the date mentioned. These steel kilns are of the Monitor continuous burning pattern, about 11 feet in outside diameter and 40 feet in height. Their output is about 200 bushels each per day. On account of greatly decreased demand for lime in the winter months but six to eight kilns are operated during that season. From 140 to 200 hands are employed from April 1st to November, the wages paid grading from $1.40 to $2.00 per day. For a number of years all the lime produced was burned with natural gas, but on account of the greatly decreased supply of that fuel it is now only used in part of the kilns during the summer months, and is then supplemented by wood. Hocking Valley, Ohio, coal is the principal fuel used in the winter and spring.

The rock used in making lime in the vicinity of Huntington is a magnesian Niagara limestone, very similar in appearance and chemical composition to that used at Delphi. In regard to the dip of the stone, Mr. L. C. Ward, who prepared for me the accompanying map of the Huntington Lime District, writes: "As to the dip of the rock in the different quarries, nothing definite in the way of figures can be given. Even in the same hole, the dip may vary widely in pitch and in direction. All those west of town dip toward the south and southeast, the pitch varying between 3° and 30°. The latter number is for the quarry marked R, within the city limits. For the neighboring quarries, 3° to 15° are the prevailing dips.

"In the quarries east of town, a greater degree of regularity is noticeable. The quarry marked B has level strata, the dip being considerably less than 1°. All the other quarries in sections 13, 12 and 7 have their strata dipping to the northwest, or northwest by north. The average dip is 12°; it sometimes reaches 15°




Huntington Lime District.

Legend.

A = Abandoned Quarry.

L = Lime Quarry

R = Road-Material Quarry

B = Building-stone

OOO = Active Kiln.

and rarely drops to 10°. In the large quarry marked L, section 13, the dip in the northern part of the hole is 15° to the northwest; in the southern part, 12° to the southwest. In section 8, the strata in the quarry marked L have a dip of 10° to the north and northeast. These great variations in dip point to a greatly complicated set of folds or faults, or both. The overlying mantle of drift, however, precludes any closer study of the strata relations underneath."

In the main quarry, L. (n. w. quarter section 13) used by the Western Lime Company, about 36 inches of stripping is removed and the stone then quarried to a depth of 53 feet. There is no waste except some fine material which accumulates on the bottom and which would choke the kilns if used. The quarry covers several acres and the stone, after being blasted and broken to the required size, is loaded into cars and then hauled by horse-power along temporary tramways to the foot of an incline from which it is raised by steam-power to a platform above the kilns. The cars hold 30 cubic feet of stone, and 26 of them are required to make 450 bushels of lime.

The lime made by the Western Lime Company is a magnesian lime, much the same in character as that burned at Delphi. For mortar making it is "cool" and slow-setting, and where used in paper factories it is claimed that it does not gum the cylinders as does a lime made from pure calcium carbonate. For that reason it is sold to a number of the larger paper and strawboard factories of Indiana and adjoining states. About 35 per cent. is shipped in barrels, the remainder in bulk. The price at the kilns in October, 1903, was 13 cents per bushel or 60 cents per barrel; in car-load lots it brought about two cents less per bushel. An analysis of the lime made for the company in March, 1897, by T. W. Smith of Indianapolis, showed its chemical composition to be as follows:

ANALYSIS OF LIME FROM THE WESTERN LIME CO., HUNTINGTON, IND.

| | |
|---|---|
| Calcium oxide (CaO) | 63.03 |
| Magnesium oxide (MgO) | 34.15 |
| Ferric oxide and alumina ($Fe_2O_3$+$Al_2O_3$) | 2.62 |
| Silica ($SiO_2$) | .07 |
| Moisture | .13 |
| Total | 100.00 |

The combined calcium and magnesium oxides, which form the quicklime, show it to be 97.18 per cent. pure lime.

THE CONSOLIDATED LIME COMPANY.—The plant of this company is located on a switch of the Wabash Railway, two and a half miles east of Huntington, in the northwest quarter of the southwest quarter of section 8 (28 N., 10 E.). (See accompanying map.) The first kilns, two in number, were erected in 1893, and two more were built in 1894. These were stone pot kilns. In March, 1903, the company replaced these by three steel kilns of the latest pattern, and in October had the foundations in and the steel ordered for three additional ones. The capacity of the six kilns will be 1,500 bushels each 24 hours. The kilns are 10 feet in outside diameter by 42 feet in hight, 8 feet of the latter dimension being taken up by the cooling and drawing pit. When the new kilns are completed the company will have about $30,000 invested. Twenty men are employed, the burners and drawers receiving $12.00 per week of seven days; the quarrymen, $1.50 per day. "Black Hawk" bituminous coal from southern Indiana is used as fuel. Firing is done every three-quarters of an hour, and the lime is drawn every four hours, 30 to 40 bushels to the kiln, the amount depending upon the draught or indirectly upon the density of the air.

The Consolidated Lime Company owns 24 acres of limestone land in the immediate vicinity of the plant, the quarry being just south of the kilns on the bank of the Little Wabash River. Two or three feet of stripping is removed and all the stone is then used; the quarry being opened to a depth of 18 feet. The strata have a decided dip of 10° or more to the north and northeast. The stone is a grayish to buff magnesian limestone whose chemical composition, according to R. E. Lyons, is as follows:

ANALYSIS OF LIMESTONE FROM QUARRY OF CONSOLIDATED LIME CO., HUNTINGTON, IND.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 53.22 |
| Magnesium carbonate ($MgCO_3$) | 44.96 |
| Ferric oxide and alumina ($Fe_2O_3$+$Al_2O_3$) | .23 |
| Insoluble residue (silica, etc.) | .59 |
| Sulphuric anhydride ($SO_3$) | .11 |
| Total | 99.11 |

The stone is hauled up an incline by steam-power and dumped into kilns. It burns into a grayish lime which is said to slack quicker than that produced by the Western Lime Company. In plastering 100 square yards of surface, three barrels of the lime is sufficient.

An analysis of an average sample of this lime, made by Dr. R. E. Lyons, showed its constituents to be as follows:

ANALYSIS OF LIME FROM CONSOLIDATED LIME CO., HUNTINGTON, IND.

| | |
|---|---|
| Calcium oxide (CaO) | 59.20 |
| Magnesium oxide (MgO) | 38.38 |
| Ferric acid and alumina ($Fe_2O_3+Al_2O_3$) | .49 |
| Insoluble residue (silica, etc.) | .35 |
| Moisture | 1.80 |
| Total | 100.22 |

The combined calcium and magnesium oxides which form the lime show a percentage of 97.58, thus proving the purity and excellent quality of the lime. The latter has, up to the present, been sold for building purposes alone and the demand has exceeded the supply. The price in October, 1903, was 12 cents a bushel, or 58 cents a barrel, f. o. b. the cars at the kiln. The market is at present principally in Indiana, but when the new kilns are in place, the company hopes to extend the trade into adjoining states. The quality of the lime produced will, without doubt, aid them in realizing their expectations.

## At Markle Huntington Co., Ind.

Markle is a town of 750 population, located in Rock Creek township, Huntington County, nine miles southeast of Huntington on the Chicago & Erie Railway. The most eastern outcrop of Niagara limestone in Huntington County is just south of Markle, on the Wabash River. It has a blue-green color, is irregular in fracture, and usually occurs in four to six-inch layers. The strata have a local dip of 20° to the southeast. The outcrop may be followed for two or three miles up and down the stream. An analysis of the stone, made by E. T. Cox,* showed its chemical composition to be as follows:

*7th Ann. Rep. Geol. Surv. of Ind., 1875, p. 119.

ANALYSIS OF NIAGARA LIMESTONE FROM MARKLE, IND.

| | |
|---|---|
| Lime | 37.56 |
| Magnesia | 7.58 |
| Carbonic acid and combined water | 48.50 |
| Iron and alumina | 2.50 |
| Insoluble matter | 2.25 |
| Moisture | .75 |
| Sulphuric acid | .27 |
| Total | 99.41 |

The Markle stone was first used for lime in 1888. The kilns, located just south of the corporate limits, were operated for a few years and then closed down until 1902, when the present proprietor, Mr. E. S. Wheeler of Huntington, assumed control. Three stone pot kilns of the intermittent pattern are used, their capacity being 1,000 bushels each. Wood costing $1.75 per cord is used for fuel, the lime being sold as "Wood-burnt White Lime." The proprietor claims that the lime rock contains less sand than that used at Huntington; that it will yield more lime and that the latter will slack quicker than the Huntington lime. About $3,000 is invested in the plant. In 1903, 35,000 bushels of lime were produced, which sold for 12 cents per bushel, or about $4,000. The plant is operated ten months in the year and employs six men.

## At Keesport, Cass County.

Keesport is an abandoned station on the Wabash Railway, four miles east of Logansport, the county seat. Large outcrops of a very pure limestone occur along the Wabash River in the immediate vicinity. The burning of lime from one of these deposits was begun by A. B. Keeport & Co. in 1868, and was continued until 1901, when the industry was abandoned, on account of the deposit of stone owned by the firm becoming exhausted. Four continuous burning stone kilns were in use, the capacity of the plant being 1,000 bushels per day. From 1892 to 1896, 220,000 to 250,000 bushels of lime were burned each year. The output was an excellent quality of white lime, which was sold mainly for building and chemical uses. An analysis of the stone made for the firm by Dr. J. N. Hurty showed its composition to be as follows:

ANALYSIS OF LIMESTONE FORMERLY BURNED INTO LIME AT KEESPORT, CASS COUNTY, INDIANA.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 96.02 |
| Silica ($SiO_2$) | 1.02 |
| Alumina and iron oxide ($Al_2O_3+Fe_2O_3$) | 2.00 |
| Magnesium carbonate ($MgCO_3$) | 1.04 |
| Total | 100.08 |

## Near Ingalls, Madison County, Ind.

Ingalls is a town of 600 population, situated 23 miles northeast of Indianapolis, on the Cleveland Division of the Big Four Railway, in the southeastern corner of Madison County.

Beds of a very pure limestone outcrop at a number of places north and northeast of Ingalls. At a point about three-quarters of a mile north of the town the Ingalls Lime and Stone Company erected two modern steels kilns in 1891 and began the burning of lime, with natural gas as fuel. The industry was discontinued in 1894, as no switch had been put in and the lime had to be hauled to Ingalls in wagons and there loaded into cars. The product was a "short," quick-slacking lime. It was sold to glass and strawboard manufacturers and for building purposes, and gave good satisfaction wherever used.

The company owns 66 acres of land about the quarry from which the stone for lime making purposes was taken. The stone lies within two feet of the surface over most of this tract. It is at present quarried and ground for glass making purposes and for a fertilizer. It is mostly in thin layers, which break into fragments when blasted. An analysis of it made by Dr. W. A. Noyes, shows its composition to be as follows:

ANALYSIS OF LIMESTONE FROM NEAR INGALLS, IND.

| | |
|---|---|
| Silica ($SiO_2$) | 5.85 |
| Alumina ($Al_2O_3$) | 0.77 |
| Ferric oxide ($Fe_2O_3$) | 0.16 |
| Calcium carbonate ($CaCO_3$) | 93.17 |
| Magnesia (MgO) | 0.25 |
| Combined water ($H_2O$) | 0.08 |
| Total | 100.28 |

On account of the low percentage of magnesia present the stone is very suitable for making Portland cement.

### Near Utica, Clark County.

Utica is a town of small size located on the Ohio River in the southern part of Clark County six miles above Jeffersonville. Thick outcrops of Niagara limestone occur near the town, and lime was first burned from these in temporary kilns by M. H. Tyler and H. C. Emmericke in 1868. In 1871, J. B. Speed & Co. leased some of the stone land and erected three permanent kilns of 800 bushels capacity. These they have since continued to operate, but at present use only one kiln having 300 bushels daily output. This is located about a quarter of a mile northeast of Utica. The stone used is a very fine magnesian carbonate which burns into a lime of high repute for mortar and plaster. Pittsburgh nut and slack coal is used for fuel. The lime is marketed at Louisville and Ohio River points above Utica. In 1903, 13,385 barrels of 2¼ bushels each were produced, but the average annual output for the last seven years has been but about 8,000 barrels. The Union Lime and Cement Co. also operated several kilns near Utica up to about 1900, when they discontinued, mainly on account of lack of transportation facilities.

### At Milltown, Crawford County, Ind.

Milltown is located 34 miles northwest of Louisville, on the St. Louis Division of the Southern Railway. The town has a population of about 450 and is situated on Blue River, which here forms the line between Harrison and Crawford counties. The river at that point is about 225 feet wide and between there and its mouth at the Ohio River has a fall of 89 feet, or about seven and a half feet to the mile. Many places are available for impounding dams, which could be built from 20 to 40 feet high. The stream thus furnishes one of the best unutilized sources of water-power in southern Indiana.

J. B. Speed & Co.—This company, whose main office is at Louisville, Kentucky, has been making lime at Milltown since 1887. The plant is located on the west side of Blue River, in

Crawford County, and is operated in connection with a large rock-crushing plant whose output is used for ballast and macadam. In the lime plant, four kilns are in use, two of steel and two of stone, the total capacity of which is 1,500 bushels of lime per day. The burning is by the older style of the continuous process kiln in which both fuel and stone are put into the kiln in alternate layers, from the top. The greatest diameter of the stone kilns is about one-third their height above their base. From this they taper gradually down to the "eye" or draw pit. Their capacity is about 375 bushels per day, that of the steel kilns being a little more. Indiana coal from the Ayrshire mines near Oakland City, is used as fuel. Each draw of stone requires from 36 to 48 hours to convert it into lime.

The stone used is Mitchell limestone from certain beds of the quarry which is operated for crushed stone. A detailed section of this quarry is as follows:

SECTION EXPOSED AT J. B. SPEED QUARRY, MILLTOWN, IND.

| | | *Feet.* | *Inches.* |
|---|---|---|---|
| 1. | Buff, weathered limestone | 1 | 8 |
| 2. | Coarsely crystalline limestone, with numerous crinoid stems | 2 | 0 |
| 3. | Pure white oölitic limestone, with few fossils | 4 | 0 |
| 4. | Light buff to drab lithographic limestone | 5 | 0 |
| 5. | Greenish shale | 0 | 4 |
| 6. | Gray lithographic limestone | 0 | 10 |
| 7. | Greenish-gray shale, intercalated with bands of lithographic limestone, two to eight inches thick | 0 to 1 | 6 |
| 8. | Gray, lithographic limestone | 7 | 0 |
| 9. | Soft, granular, buff magnesian (?) limestone | 3 to 4 | 0 |
| 10. | Lead gray, fine-grained, crystalline limestone | 3 to 4 | 0 |
| 11. | Pure white oölitic limestone | 5 | 0 |
| 12. | Calcareous shale | 2 in. to 0 | 4 |
| 13. | Gray oölitic to sub-oölitic limestone | 4 | 6 |
| 14. | Limestone with black chert | 1 in. to 0 | 8 |
| 15. | Drab colored, impure limestone | 4 | 0 |
| 16. | Bluish gray lithographic limestone | 0 to 0 | 10 |
| 17. | Dark gray, sub-oölitic to sub-crystalline limestone | 8 | 0 |
| 18. | Very soft, drab colored, magnesian limestone | 6 | 0 |
| 19. | White oölitic limestone | 6 | 0 |
| 20. | Gray limestone | 16 | 0 |

The beds used for lime are Nos. 3, 11 and 17. Nos. 3 and 11 are composed of oölite or oölitic limestone of very great purity.

They correspond to similar beds in the Eichel quarry across the river, a chemical analysis of which showed the presence of 98.91 per cent. carbonate of lime.

The stone, after being blasted and broken to the proper size, is loaded into cars and hauled by steam-power up an incline to the top of the kilns; 26.4 cubic yards constituting what is termed a draw or one day's burning. This produces 375 bushels of lime. On account of the process of burning in use, quite a good deal of trouble is experienced with "cores" or centers of the larger pieces of stone which pass through the kilns unburned. Two men are required to separate these when the product is shipped in bulk.

The lime made from beds Nos. 3 and 11 is very white; that from No. 17 is a darker gray in color. The lime is termed "hot" or quick-setting by masons. An analysis of an average sample, made by Messrs. Burk & Arnold, of Louisville, Ky., showed its composition to be as follows:

ANALYSIS OF LIME FROM J B SPEED & CO., MILLTOWN, IND.

| | |
|---|---|
| Calcium oxide (CaO) | 98.24 |
| Magnesium oxide (MgO) | .56 |
| Ferric oxide and alumina ($Fe_2O_3$+$Al_2O_3$) | .42 |
| Insoluble residue (silica, etc.) | .30 |
| Moisture | .54 |
| Total | 100.06 |

The lime is sold mainly in southern Indiana, Illinois, Ohio and West Virginia. In September, 1903, it was bringing 12½ cents per bushel, or 60 cents per barrel at retail at the plant. Fifty per cent. was being shipped in barrels, the remainder in bulk in carload lots. About ten per cent. went to paper manufacturers, the remainder being sold for building purposes. Forty men were employed in the lime industry by the company. Their wages ran from $1.30 per day for the quarrymen to $2.00 per day for experienced burners. The plant is run the year around, but with a decreased output in the winter months. The lime has a wide reputation for purity and, in the region where sold, is preferred to the slower setting limes made from the Niagara limestone.

Besides the ordinary quicklime, the J. B. Speed Company make a hydrated lime of two grades, the best of which is sold under the

name of "White Rock Finish." A separate plant a few rods north of their kilns is used in its preparation. The No. 1 grade of hydrated lime is made from ordinary quicklime by first crushing, then grinding to extreme fineness. The ground product is then mixed with a certain quantity of water, after which it is passed through a fine bolting cloth. As it issues from this it resembles a very fine flour, but is much lighter, bulk for bulk. It is sold in sacks of two sizes, either cloth or paper, which hold 40 pounds or 100 pounds.

When mixed with water, this hydrated lime is ready for immediate use, and possesses all the qualities of lime putty. It does not air slack and can be applied to almost any purpose for which lime is commonly used, being especially suitable in those lines of manufacture where a dry, inert, carefully seasoned preparation of lime is required. In its use for mortar making, a saving both of time and of water is effected.

In the making of No. 2 hydrated lime an inferior grade of quicklime is used, the same being air-slacked lime from the kilns and portions which have become fused with cinders while passing through them. The process of manufacture is the same as for the No. 1 grade, except that it is not passed through the bolting cloth. It brings $2.50 per ton and is sold in bulk as a top dressing for soils, mainly to Illinois farmers. It is not used as a fertilizer, but as a material for improving the mechanical condition of soils.* The J. B. Speed Company has the only plant for making hydrated lime in the State, and has made quite a success of the business. Similar plants are said to be in operation in northern Ohio.

EICHEL LIME AND STONE CO.—The plant of this company is located on the east side of Blue River, in Harrison County, about one-quarter of a mile east of the Speed plant. As with the former, the lime industry is carried on in connection with that of preparing crushed stone. The company began the burning of lime in 1903. Three steel kilns are in operation, each of which is 36 feet in height and 20 feet in outside diameter. The process of burning is the same as that of the Speed Company, the kilns being charged at the top with alternate layers of stone and coal. The latter is shoveled in in such a manner as to spread evenly over the center

*See "Uses of Lime," on p. 216.

of the kiln. The outer edge of the layer of coal should not be nearer than one foot to the inner edge of the kiln; otherwise the latter is apt to become too hot, thus causing the partially burned lime to stick to it. If the coal is heaped in the center of the kiln, it is apt to smother down the fire. Ayrshire coal is used as fuel, it being as free from sulphur as any obtainable along the Southern Railway.

The stone used is of the same nature as that used by the plant across the river, the Eichel Company owning 26 acres of stone land surrounding their quarry. A section down the face of the quarry showed the presence of the following beds:

SECTION AT EICHEL QUARRY ON EAST SIDE OF BLUE RIVER, OPPOSITE MELLTOWN, IND.

| | | *Feet.* | *Inches.* |
|---|---|---|---|
| 1. | Light drab and light brown lithographic limestone | 7 | 0 |
| 2. | Light and bluish drab calcareous shale | 1 | 3 |
| 3. | Light drab, lithographic limestone, slightly cross-bedded, with thin lines of coarse sand grains especially toward the top | 12 | 0 |
| 4. | Light gray limestone | 9 | 0 |
| 5. | White to dark gray oölitic limestone, oölitic structure not distinct | 13 | 0 |
| 6. | Hard blue, sub-crystalline, sub-oölitic limestone, (crowfeet) | 6 | 8 |
| 7. | Bluish green shale | 0 | 2 |
| 8. | Light gray, granular limestone, one notable crow-foot near the middle, accompanied with some green matter | 5 | 0 |
| 9. | Shale parting | 0 | 1 |
| 10. | Interlayered gray crystalline and oölitic limestone | 3 | 9 |
| 11. | Lithographic limestone in thin layers, with shale partings | 2 | 0 |
| 12. | Drab lithographic limestone, with calcareous bands and nodules | 3 | 6 |
| 13. | Gray crystalline limestone | 0 | 2-6 |
| 14. | Lithographic limestone, with numerous flint bands and nodules | 7 | 0 |
| 15. | To river, about | 10 | 0 |

The main bed used for lime is No. 5 of the above section. With it is combined portions of Nos. 3, 6, 8 and 10 of the section; in all about 38 feet. An analysis of the oölite from bed 5, made for this Department by Dr. W. A. Noyes, showed its chemical composition to be as follows:

ANALYSIS OF OÖLITE USED IN LIME MAKING AT EICHEL QUARRY, MILLTOWN, IND.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 98.91 |
| Magnesium carbonate ($MgCO_3$) | 0.63 |
| Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$) | 0.15 |
| Insoluble in hydrochloric acid | 0.48 |
| Total | 100.17 |

Another analysis showing the average composition of six limestone beds of the quarry, including the oölite bed, resulted as follows:

ANALYSIS OF AVERAGE SAMPLES FROM SIX BEDS OF EICHEL'S QUARRY.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 96.87 |
| Magnesium carbonate ($MgCO_3$) | 1.19 |
| Silica ($SiO_2$) | .51 |
| Alumina ($Al_2O_3$) | .37 |
| Total | 98.94 |

The stone is loaded at the quarry into steel cars, which are drawn up an incline to the top of the kilns, where they are dumped automatically. About 20 cubic yards are used for a draw of 360 bushels. Each draw is about four days in passing through the kiln, but is in actual contact with the fire about 36 hours. The oölite stone loses fully half its weight while being changed into lime.

The Eichel lime, like that from the Speed kilns, is a hot lime, which slacks very quickly. It is also termed a "strong" lime; i. e., a bushel of it will, it is claimed, make more mortar than that produced farther north. About eight per cent. is sold to paper manufacturers, and quite a quantity is ground and goes to glass works, especially to bottle glass factories. The greater quantity is sold for mortar and plaster; the principal markets being in Indiana, Illinois, Kentucky and Missouri. The retail price is the same as at Speed's kilns, the wholesale price not being given. The plant is operated throughout the year. Twenty hands are employed in the quarry and at burning, at wages ranging from $1.30 to $2.00 per day. Besides these, five coopers are engaged in making barrels, for which they receive four cents apiece; an average of 50 being completed in a day by each man.

## At Salem, Washington County.

Salem, the county seat of Washington County, is a town of 2,000 population, located on the C., I. & L. (Monon) Railway, 41 miles northwest of Louisville, Kentucky. The quarries of Bedford oölitic limestone near which the limekilns are situated, are in the northwest quarter of section 19 (2 N., 4 E.) one mile west and a little south from the courthouse. They were first operated under the name of the "Salem Stone & Lime Co.," and then for a time under that of "The Salem-Bedford Stone Company." In 1896 Mr. Hopkins wrote of them as follows: "These quarries were for many years worked quite extensively and produced some excellent building stone which went into fine buildings. The Georgia statehouse is constructed of this stone, as is the Salem courthouse, one of the neatest courthouses in western Indiana. There are a half dozen different but closely adjoining openings along the bluff running south from the railway on the west side of the branch road made by the company. The bottom of the stone is concealed either by water or debris at present, so that the total thickness of the stone is not shown. The walls show from three to five channel cuts, or from 20 to 30 feet, with three to 20 feet of rock and soil stripping. The stone has a medium fine grain; no large fossils were observed. The greater part of the stone is buff, yet in a few places a little blue stone occurs. There is a large stone mill and a number of limekilns at the quarry, but the mill is now idle. Most of the channelers have been removed and there appears to be very little dimension stone being quarried.

"A unique feature of this quarry is the absence of the large dump piles of waste stone, the universal accompaniment of the quarries elsewhere. The explanation of this is found in the limekilns at the quarry, where all the waste stone is burned to quicklime and marketed in that form. The only stone that is being quarried at present (July, 1896) is the broken stone for lime burning."*

The Union Cement and Lime Co.—The first lime was burned from the Bedford oölitic stone at the Salem quarries about 1884.

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*"The Bedford Oölitic Limestone of Indiana," in 21st Ann. Rep. Ind. Dept. Geol. and Nat. Res., 1896, p. 394.

In 1898 the property passed into the control of the Union Cement and Lime Company, whose main offices are at Louisville, Kentucky. This company at present controls 50 acres of stone land in the immediate vicinity of their plant. The latter is located on a spur of the Monon Railway, a dummy engine, owned by the company, doing the switching.

Five continuous process kilns are used in burning the lime, three of which were in operation in October, 1903. Four of the kilns are of stone; the other of steel. The dimensions of the stone kilns are, base, 22 feet square; top, 18 feet square; height, 38 feet above the drawpit. The stone kilns have a capacity of 250 bushels each and the steel kilns 175 bushels, per day. Wood, oil and coal have all been used as fuel, the use of the first two having been abandoned on account of increase in cost. The coal used in 1903 was nut and slack from Wolfman's mine near Huntingburg, Dubois County, and cost $1.40 per ton, delivered at the plant. The firing is done in furnaces located at the base of the kilns, above the drawpit. Blowers are used in all furnaces to increase the draught.

The quarry from which the stone is at present obtained is located just back of the lime plant, and disclosed the following section:

SECTION OF QUARRY NEAR KILNS OF UNION CEMENT AND LIME CO., SALEM, IND.

| | | |
|---|---|---|
| 1. | Soil, surface clay and weathered stone (stripped)... | 5 feet |
| 2. | Buff to gray oölitic limestone..... | 8 feet |
| 3. | Bastard oölitic stone..... | 10 feet |
| 4. | Buff to blue oölitic limestone (massive)..... | 30 feet |

The stone used in making lime is from beds 2 and 4 of the section. The bastard stone, bed 3, burns into a yellow lime, which makes a tough putty-like plaster, hence the whole ledge has to be discarded and hauled to one side thus increasing the cost of the lime produced. The stone is first blasted and then broken by sledge or squib blast into small pieces. That from ledge No. 2 is hauled up an incline to the top of the kilns, while that from the deeper ledge, No. 4, is raised by derricks. The latter will be abandoned as soon as room enough is afforded for an incline to the bottom of the quarry. No analysis of the stone used for lime was available, but it is very similar in composition to that from the Twin Creek quarries, about seven miles northwest, whose analysis

showed the presence of 98.16 per cent. of carbonate of lime, .97 per cent. of carbonate of magnesia, and only .91 per cent. of impurities. The kilns are filled by day and topped up for night burning. Bins at the top hold stone enough for two or three days' burning when severe weather is experienced. The plant is operated all the year, except for two or three weeks in midwinter. But little trouble is experienced with "cores."

The lime is drawn every eight hours, the output for the three kilns in operation at the time of my visit being 750 bushels daily. It is at first rather dark in color, but becomes pure white when slacked. It is a "hot" lime, which slacks quickly and is evidently very pure in composition. It is used mainly for mortar and plaster, though large quantities are sold to tanneries and paper mills. It is shipped wholly in bulk, and goes mainly to Louisville, from which point it is distributed by the company. At Salem, where there is no competition, it is retailed at 20 cents per bushel. The cost of production is estimated at about 9½ cents on board cars. The company refused to give information regarding the wholesale selling price, or to furnish analysis of either lime or stone, but an analysis of the lime made by Chauvenet & Bro., of St. Louis, showed its constituents to be:

| | |
|---|---|
| Calcium oxide (CaO) | 96.93 |
| Magnesium oxide (MgO) | .85 |
| Silica ($SiO_2$) | 2.22 |
| Total | 100.00 |

Twenty men are employed in and about the plant, their wages ranging from $1.25 for quarrymen to $1.60 per day for foremen and chief burners.

## At Mitchell, Lawrence County.

Mitchell, a town of 2,500 population, is located in the southern part of Lawrence County at the junction of the C., I. & L. (Monon) and B. & O. S. W. railways, 67 miles northwest of Louisville, and 127 miles west of Cincinnati. The Mitchell limestone, of which mention has been made a number of times in this paper, takes its name from the town, which is located on this stone.

Lime has long been burned from the Mitchell limestone in the vicinity of the town. The first kilns were of the temporary ground-hog pattern. They were in time replaced by the more permanent intermittent burning stone pot kilns. One of the first men in the region of Mitchell to make the burning of lime his principal industry was Asa Erwin, who operated several of these pot kilns 40 or more years ago. John Collett, in his report on the Geology of Lawrence County, published in 1873, makes mention of Erwin and his industry as follows: "Mitchell lime is favorably known to the trade. Asa Erwin, on a branch of Rock Lick Creek, N. E. quarter section 24 (4 N., 1 W.), uses a common kiln, capable of burning one thousand bushels at a time. His annual product is seventeen thousand five hundred bushels, which sells at twenty cents per bushel delivered on the cars. The product is a white lime, which works 'hot,' and is found to be nearly equal to cement for foundations. He makes use of the *Vermicular* stratum, a bluish gray limestone, massive, but traversed in every direction irregularly by tubular canals, from one-eighth to one-half inch in diameter. The stone, on account of its porous nature, is found to burn and slack with great certainty. The waste lime from this kiln has been used with remarkable profit as a manure, and the result invites further experiment."*

The Big Four Lime Company, also operated for a number of years, six or more pot kilns on the main fork of Rock Lick Creek in the northwest quarter of section 30 (4 N., 1 E.), about two miles southeast of Erwin's location. In 1895 the Mitchell Lime Company was organized and by purchase or lease secured possession of both the plants then in operation and all the adjacent stone land suitable for making lime.

THE MITCHELL LIME COMPANY.—This company now owns two large plants on or near the sites of the older pot kilns above mentioned. The larger one of these is the Monon or Rabbitville plant, located on a spur of the Monon Railway, two and a half miles north of Mitchell. The company owns 178 acres of stone land immediately surrounding the plant. On a portion of this the town of Rabbitville, consisting of about 20 neat frame houses and a good brick schoolhouse, is situated. In them live the workmen em-

*5th Ann. Rep. Geol. Surv. of Ind., 1873, p. 302.

ployed about the kilns and quarry. Six modern steel kilns, of 250 bushels capacity each are in use at this plant. The actual output of each kiln averages 200 bushels daily. Both wood and coal are used for fuel. The coal usually comes from Greene and Daviess counties, Indiana. In October, 1903, however, only Daviess County coal was being used, and it was being hauled by wagon from cars at Mitchell and cost about $2.00 a ton laid down at the plant, as against $1.70 for the same coal delivered at the other plant, the difference in cost being due to switching charges by the Monon Railway.

The quarry of Mitchell limestone, from which the stone for burning is obtained, is located just southeast of the kilns. After one to five feet of stripping, composed of soil and bluish outcropping stone, is removed, the face of this quarry discloses nine ledges of stone which are used for lime. These ledges vary in thickness from 10 inches to five feet, and comprise a total thickness of 26 feet. Below the lowermost of these and between it and the Bedford oölitic stone is a ledge 16 feet thick, which is composed of about 80 per cent. lime and 14 per cent. silica. The top of this ledge forms the floor of the quarry and is kept clean of all rubbish and broken stone by the superintendent in charge. All the strata in the quarry dip to the southwest at the rate of one foot to 100 feet, or 52 feet to the mile.

The company has had made an analysis of each of the nine ledges used for lime making. These analyses show a very close uniformity in composition, the carbonate of lime ranging only from 95.73 to 97.51 per cent. An average of the nine analyses was as follows:

AVERAGE ANALYSIS OF NINE LEDGES OF STONE USED FOR LIME MAKING AT THE MONON PLANT OF THE MITCHELL LIME CO.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 96.65 |
| Magnesium carbonate ($MgCO_3$) | 1.20 |
| Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$) | .27 |
| Insoluble residue (silica, etc.) | 1.57 |
| Total | 99.69 |

On the eastern side of the quarry, a ledge eight feet from the top, and the fourth in serial order, is more of a bluish hue than the others. It is 30 inches in thickness and is burned separately,

the resulting lime being sold for chemical uses only. The analysis of this particular ledge showed its composition to be:

ANALYSIS OF LEDGE NO. 4, AT QUARRY OF MONON PLANT OF MITCHELL LIME CO.

| | |
|---|---|
| Calcium carbonate ($CaCO_3$) | 96.46 |
| Magnesium carbonate ($MgCO_3$) | 0.00 |
| Ferric oxide and alumina ($Fe_2O_3+Al_2O_3$) | 0.16 |
| Insoluble residue (silica, etc.) | 2.46 |
| Total | 99.70 |

The stone from the quarry is raised by an inclined tramway and dumped into bins at the top of the kilns. From these bins it gradually finds its way down through the kilns, about four days elapsing before it is drawn out as lime. The drawing takes place every four hours. The pieces of lime produced are larger than the average, but contain few cores. The waste is said not to exceed five bushels to the car load.

The second or "Rock Lick Plant" of the Mitchell Lime Company, is located about one mile northeast of Mitchell, near the sites of the former kilns of the Big Four Lime Company, and on a switch of the B. & O. S. W. Railway. A rock-crushing plant is operated in connection with the lime making industry, the two being carried on in separate buildings, but a few feet apart and alongside the same switch. The company owns 149 acres of stone land in the near vicinity. Five steel kilns of the same size and pattern as those at the Monon plant are in use for burning lime.

The quarry from which the stone is obtained is opened to a depth of 30 feet, the upper 14 feet being used for lime, the lower 16 feet for crushed and ground stone. The stone used for lime contains a little more silica than that burned at the Monon plant, but otherwise is quite similar.

The lime made at Mitchell has a wide reputation for strength and purity. It is claimed by the company to be "the strongest white lime on the market." It is said to be a quick slacking, and cool working lime which, when slacked, increases largely in bulk, so that 100 pounds will make mortar enough to lay 1,000 brick.

An analysis of a freshly burned sample of the lime from the Monon plant, made by E. F. Buchanan, the chemist of the Colonial Salt Company, of Akron, Ohio, showed its composition to be as follows:

ANALYSIS OF MITCHELL LIME FROM MONON PLANT.

| | |
|---|---|
| Calcium oxide (CaO) | 97.712 |
| Magnesium oxide (MgO) | 1.150 |
| Ferric oxide and alumina ($Fe_2O_3$+$Al_2O_3$) | .328 |
| Insoluble residue (silica, etc.) | .418 |
| Carbonic oxide (CO) | .319 |
| Undetermined | .073 |
| Total | 100.00 |

On account of its purity, a large amount of the lime is sold in Chicago and Cincinnati for chemical use, caustic and soap manufacture, etc. Quite a quantity goes to paper factories, and the remainder for mortar and plaster. About 20 per cent. is shipped in barrels. The cost of barrels made at the plants was 28 cents apiece, of which amount the coopers received 3½ cents. The principal markets for the lime are in Indiana, Ohio, Michigan and Illinois. In October, 1903, the price at the kilns was 13 cents per bushel, or 60 cents per barrel of 185 pounds. In carload lots it brought about two cents less per bushel.

The Mitchell Lime Company is incorporated for $50,000, and has about $30,000 invested in the lime industry. Seventy-five men are employed, most of whom do piece-work. The wages of the burners and drawers average $14.00 per week of seven days. Quarrymen receive $1.25 to $1.50 per day, and common laborers 13 cents per hour. Five cars of lime and 10 to 12 cars of crushed and ground stone were being shipped each day from the two plants of the company in October, 1903. The plants are operated the year around, but with a decreased output in the colder months.

## Near Bedford, Lawrence County.

Bedford, the county seat of Lawrence County, is a city of 7,000 population, situated on the C., I. & L. (Monon), Southern Indiana, and a branch of the B. & O. S. W. railways, 77 miles northwest of Louisville. It has long been the center of the Oölitic Stone Industry of the State, the largest and oldest worked quarries being in its immediate vicinity. Lime has been burned from the oölitic stone at a number of localities about Bedford, but not in recent years; the burning having been done in temporary kilns for local

use in the days when transportation facilities were meager. About every oölitic quarry of any size in Lawrence and Monroe counties there are dump or "grout" piles containing thousands of cubic yards of refuse stone. This stone is as pure chemically as any sold for building purposes but on account of some flaw, such as a small crack or "crowfoot," is unsalable.

THE HORSESHOE LIME AND CEMENT COMPANY.—In 1902, the Horseshoe Lime and Cement Company was organized for the purpose of utilizing by burning into lime the spalls and waste stone which had accumulated for years at the P. M. & B. quarry, about five miles northwest of Bedford. This quarry is located on a spur of the Monon Railway in the southwest quarter of the northeast quarter of section 33 (6 N., 1 W.). The spur leading to it leaves the main line of the Monon a short distance north of the famous horseshoe curve or bend, hence the name adopted by the company. The quarry was first opened in 1889, and, having been continuously operated, the grout pile is therefore a very large one.

The kilns of the lime company, three in number, of the continuous burning pattern, are located near the center of the excavated portion of the quarry. They are of stone and are 18 feet square at the base, 4 feet at the top, and 40 feet in height. The capacity of each kiln is 250 bushels per 24 hours. The furnaces are especially arranged for burning slack coal, being enclosed like a regular boiler front. The Dorrance shaking grate, having 66 per cent. air space, is used in the furnace, and the slack coal is burned successfully without artificial draught of any kind. The fire is kept low, being not over six inches high at any time and the grate can be cleaned in a minute or two. The furnace is at no point within three feet of the body or center of the kiln, there being a four-foot arch leading back from the fire box to the kiln. The coal used comes from Linton, Indiana, and costs $1.75 per ton, laid down at the mine. This is a high price for "slack," but it is said that the freight rate on coal from Linton to Bedford, a distance of 49 miles, is the same as from Linton to Chicago, 213 miles. It is thus that the railways foster the infant industries which spring up along their lines.

The spalls or refuse stone used for lime by the Horseshoe Company are in large pieces, some of them containing 200 cubic feet. These are blasted to the required size and hauled up an incline

plane to bins or cribs six feet high on the top of the kilns. From here the stone gradually descends through the kiln, taking on an average two and a half days before issuing as lime.

Being burned from stone wholly free from dirt, and in kilns whose construction keeps it separated from all cinders, the lime made by the Horseshoe Lime Company is noted for its purity. On this account it is sold mainly to the chemical trade. It is shipped wholly in bulk in carload lots, and goes to Indianapolis, Chicago and points north and northeast. Quite a quantity is furnished to a large paper mill at Lafayette and to the Illinois Steel Company for use in the manufacture of steel Puzzolana cement. This cement is a mechanical mixture of blast furnace slag and lime slacked with a solution of soda.

Except while undergoing repairs the three kilns have been continuously in use since they were built and the demand for the lime is said to have exceeded the supply. A new kiln of the same capacity as those existing will be erected in 1904. Two analyses of the lime, made for the company, No. 1 by Chauvenet & Bro., of St. Louis, and No. 2 by T. W. Smith, of Indianapolis, showed its chemical composition to be as follows:

ANALYSES OF LIME FROM THE HORSESHOE LIME AND CEMENT CO., BEDFORD, IND

| | *No. 1.* | *No. 2.* |
|---|---|---|
| Calcium oxide (CaO) | 98.40 | 97.80 |
| Magnesium oxide (MgO) | .10 | .18 |
| Ferric oxide and alumina ($Fe_2O_3$+$Al_2O_3$) | .52 | .62 |
| Insoluble residue (silica, etc.) | .78 | 1.38 |
| Total | 99.80 | 99.98 |

For building purposes the Horseshoe lime is a "hot," strong lime, which combines with a large amount of sand in making mortar and plaster. It slacks out very fine and makes an excellent skim coat.

The fact that the Bedford oölitic limestone has long been used in lime making at Salem, coupled with the recent success of the Horseshoe Company at Bedford, should be sufficient proof of the fitness of that stone for a high grade, chemically pure lime. Immense quantities of spalls, already quarried, free from dirt and other foreign matter, exist about all the larger quarries of the region. As the demand for a pure lime increases, there is little

doubt but that much of this refuse stone will be used for lime making in kilns which will be hereafter erected.

## Near Laurel, Franklin County.

Laurel is a town of 650 population, situated in the northern part of Franklin County, on the Whitewater Division of the Big Four Railway, 54 miles northwest of Cincinnati, Ohio. The town is located near the eastern horizon of the Niagara limestone, and the stone from the vicinity has long been quarried for curbing, flagging, foundations, abutments and similar purposes.

Between 1870 and 1885 lime was burned quite extensively in the vicinity of Laurel for the Wawasee Paper Mill, which was then located on the Whitewater River, three miles above Laurel. Many farmers in the vicinity added not a little to their income by burning lime in temporary kilns for the use of the mill. When, about 1885, the latter burned, the industry was discontinued. A number of local kilns were also from time to time burned about three miles east of Laurel, but for a number of years the lime used at Laurel, Brookville and neighboring towns has been shipped in from New Paris and Springfield, Ohio, where extensive kilns are in operation.

In 1903, the Laurel Steam Stone Company, which controls the output of a large quarry near Derbyshire Falls, in section 20 (12 E., 12 N.), erected near the quarry a temporary kiln and burned two kilns, or 5,000 bushels of lime. According to John O'Hair, the president of the company, the stone used is a ledge immediately underlying the Clinton limestone, and contains 93 per cent. of carbonate of lime. The burning was done more as an experiment to determine the fitness of the lime for use in the large paper mill at Brookville, ten miles below Laurel. The lime was burned with wood, in 72 hours' time, and gave excellent satisfaction at the mill, where it was all sold. This mill uses from three to five carloads a week, and has heretofore been getting it in Ohio and northern Indiana at a cost of 13 cents or more per bushel. The Laurel Steam Stone Company say they can burn it for seven cents or less, and expect to put in a modern plant in 1904 for that purpose. Several good gas wells are located in the near vicinity, and gas will be used for fuel as long as it lasts.

# REPORT OF STATE INSPECTOR OF MINES.

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OFFICE OF INSPECTOR OF MINES,
INDIANAPOLIS, IND., February 15, 1904.

*Prof. W. S. Blatchley, State Geologist:*

Dear Sir—I have the honor to submit to you herewith my fifth annual report as Inspector of Mines, covering the calendar year of 1903, and being the Twenty-fifth Annual Report of this Department, and the thirteenth made to the Department of Geology and Natural Resources.

I trust it will receive your approval and be found worthy of consideration by the public.

JAMES EPPERSON,
Inspector of Mines.

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# INTRODUCTION.

The subject matter of this report is treated under the several captions—

Review of coal trade.
Labor conditions.
Mine casualties.
Statistical.

In the review of coal trade, all of the mining conditions existing in 1903, including the railroad service, is treated as fully as possible.

Under the head of labor conditions we include strikes, Terre Haute and Brazil agreements, and other conditions pertaining to labor. Under mine casualties, various tables are given, exhibiting the cause, number and frequency of accidents to mine employes, also accidents to mine property.

The statistical part of the report gives tables showing the production of coal, number of mine employes, number of mining machines in use, number of mules, number of kegs of powder, tables of averages and comparative tables. These same subjects have all been treated in our former reports. However, by referring to the table of contents, it will be found that we have given some additional information which will be of interest and value to the general public. The production of coal and its distribution and the wages paid to employes have been treated in the same general manner as in our former reports. Mine accidents have been put in more complete form, in tables showing the age and nationality of persons killed and the number of dependents left at each death.

There has also been included the following additional tables, viz: a table showing the number of kegs of powder used in the mines during the year 1903, the price paid per keg and the number of tons of coal produced per keg; a table of mine haulage showing the number and kind of motors in use, and the number of

mines at which rope haulage is used (the same table shows the number of steam boilers, number of dynamos, and the number of compressers in use at Indiana mines), and a table showing by counties the name of mines using box car loaders; a table giving the average price per ton for machine and pick mining from 1900 to 1903, inclusive; also the percentage of gain over 1900.

Assistant Inspector of Mines, Charles Long, resigned September 15, and Jonathan Thomas, of Carbon, was appointed to fill the vacancy. His work in inspections and reports has been eminently satisfactory.

# TABLE,

*Showing by Months and by Counties the Number of Tons Mined and Wages Paid to Employes for the Year 1903 at Mines Employing More Than Ten Men.*

| MONTHS. | CLAY COUNTY. | | DAVIESS COUNTY. | |
|---|---|---|---|---|
| | Tonnage. | Wages. | Tonnage. | Wages. |
| January | 148,913 | $137,440 40 | 21,265 | $19,280 41 |
| February | 129,257 | 123,294 13 | 17,772 | 16,778 13 |
| March | 105,127 | 111,976 05 | 12,125 | 11,584 95 |
| April | 61,505 | 88,794 64 | 11,712 | 12,082 71 |
| May | 72,630 | 94,035 42 | 17,663 | 18,079 84 |
| June | 82,746 | 107,215 42 | 17,818 | 17,788 82 |
| July | 82,746 | 104,695 42 | 14,543 | 14,662 65 |
| August | 91,740 | 110,283 65 | 3,380 | 3,388 20 |
| September | 110,666 | 131,249 92 | 15,388 | 15,980 13 |
| October | 125,242 | 147,322 89 | 21,286 | 23,120 50 |
| November | 101,901 | 124,878 07 | 16,748 | 19,561 19 |
| December | 109,958 | 134,322 05 | 21,459 | 23,184 09 |
| Total | 1,222,431 | $1,415,508 06 | 191,159 | $195,442 12 |

| | FOUNTAIN COUNTY. | | GIBSON COUNTY. | |
|---|---|---|---|---|
| January | | | 8,196 | $3,976 83 |
| February | | | 6,111 | 5,510 79 |
| March | | | 6,615 | 5,708 96 |
| April | | | 4,440 | 4,456 36 |
| May | | | 1,260 | 1,419 55 |
| June | 207 | $379 50 | 2,050 | 3,172 58 |
| July | 3,717 | 3,194 40 | 2,320 | 4,674 08 |
| August | 2,329 | 2,048 29 | 2,896 | 4,921 19 |
| September | 2,395 | 1,742 00 | 3,967 | 5,330 38 |
| October | 2,411 | 1 993 00 | 1,099 | 2,988 93 |
| November | 2,728 | 1,927 00 | 3,378 | 4,234 57 |
| December | 2,748 | 2,052 00 | 4,368 | 4,838 84 |
| Total | 16,635 | $13,336 19 | 46,700 | $51,233 06 |

| | GREENE COUNTY. | | KNOX COUNTY. | |
|---|---|---|---|---|
| January | 207,263 | $177,988 94 | 14,902 | $12,706 01 |
| February | 176,073 | 113,136 58 | 11,922 | 10,096 65 |
| March | 213,253 | 155,856 36 | 12,316 | 9,693 43 |
| April | 132,928 | 119,388 85 | 8,372 | 6,937 11 |
| May | 143,737 | 132,801 63 | 8,811 | 7,059 96 |
| June | 149,310 | 136,216 21 | 9,457 | 8,115 18 |
| July | 167,108 | 152,163 39 | 7,144 | 6,565 66 |
| August | 166,061 | 145,150 04 | 7,783 | 6,224 38 |
| September | 191,480 | 169,861 38 | 10,956 | 15,014 20 |
| October | 226,350 | 198,018 03 | 13,689 | 12,517 42 |
| November | 225,026 | 195,092 70 | 16,549 | 13,482 27 |
| December | 228,202 | 192,371 33 | 16,048 | 14,179 24 |
| Total | 2,226,789 | $1,888,045 39 | 137,949 | 122,591 61 |

| MONTHS. | PARKE COUNTY. | | PERRY COUNTY. | |
|---|---|---|---|---|
| | Tonnage. | Wages. | Tonnage. | Wages. |
| January | 66,766 | $96,818 83 | 1,419 | $1,436 04 |
| February | 82,239 | 85,746 06 | 1,164 | 856 35 |
| March | 96,457 | 87,297 64 | 1,200 | 1,027 11 |
| April | 41,905 | 53,884 03 | 1,124 | 1,070 49 |
| May | 50,218 | 65,015 92 | 799 | 785 50 |
| June | 56,282 | 74,067 83 | 1,016 | 962 01 |
| July | 66,948 | 82,959 70 | 1,106 | 1,115 35 |
| August | 79,068 | 99,453 89 | 615 | 649 25 |
| September | 85,019 | 104,350 54 | 691 | 869 03 |
| October | 99,995 | 118,260 48 | 849 | 947 83 |
| November | 84,052 | 104,298 52 | 786 | 969 77 |
| December | 113,955 | 113,871 72 | 451 | 525 62 |
| Total | 923,994 | $1,086,504 26 | 11,120 | $11,115 35 |

| | PIKE COUNTY. | | SULLIVAN COUNTY. | |
|---|---|---|---|---|
| January | 58,636 | $48,542 56 | 1 | $104,955 00 |
| February | 46,231 | 38,300 06 | 3 | 93,230 36 |
| March | 52,274 | 43,478 35 | 8 | 96,240 74 |
| April | 33,307 | 27,144 71 | 7 | 82,858 38 |
| May | 27,966 | 23,826 00 | 4 | 84,547 27 |
| June | 28,833 | 23,422 16 | 9 | 97,825 52 |
| July | 27,203 | 20,552 88 | 8 | 101,756 77 |
| August | 34,612 | 33,305 64 | 9 | 117,939 01 |
| September | 44,843 | 42,419 56 | 0 | 123,671 07 |
| October | 54,404 | 50,062 51 | 5 | 113,602 97 |
| November | 39,449 | 37,912 65 | 6 | 126,746 77 |
| December | 43,016 | 40,965 91 | 8 | 122,361 13 |
| Total | 494,256 | $449,931 99 | 1,563,330 | $1,264,436 99 |

| | VANDERBURGH COUNTY. | | VERMILLION COUNTY. | |
|---|---|---|---|---|
| January | 28,035 | $18,645 59 | 74,010 | $53,347 58 |
| February | 22,661 | 16,198 87 | 81,961 | 60,535 37 |
| March | 15,278 | 11,964 71 | 84,634 | 62,306 09 |
| April | 9,886 | 9,968 06 | 49,139 | 31,095 39 |
| May | 11,439 | 11,413 49 | 63,260 | 51,952 75 |
| June | 9,600 | 10,172 17 | 76,445 | 61,086 12 |
| July | 12,607 | 12,812 71 | 84,433 | 68,106 28 |
| August | [illegible] | 14,335 96 | 82,472 | 67,183 38 |
| September | [illegible] | 19,254 98 | 80,170 | 64,747 20 |
| October | [illegible] | 25,442 16 | 77,424 | 67,233 01 |
| November | [illegible] | 21,347 63 | 94,146 | 80,642 67 |
| December | 20,830 | 21,169 25 | 94,152 | 80,462 87 |
| Total | 204,648 | 192,735 78 | 942,185 | $748,447 77 |

| | VIGO COUNTY. | | WARRICK COUNTY. | |
|---|---|---|---|---|
| January | 165,397 | $144,136 82 | 30,886 | $19,063 73 |
| February | 136,269 | 122,126 61 | 26,199 | 15,183 95 |
| March | 128,887 | 105,251 85 | 25,481 | 18,308 34 |
| April | 205,625 | 86,076 80 | 20,661 | 15,191 91 |
| May | 106,336 | 105,933 90 | 15,572 | 12,963 22 |
| June | 116,111 | 102,767 82 | 21,444 | 14,707 26 |
| July | 137,471 | 121,359 55 | 19,967 | 12,974 32 |
| August | 137,318 | 128,638 43 | 25,554 | 18,022 16 |
| September | 141,329 | 134,227 00 | 24,744 | 18,463 02 |
| October | 146,334 | 154,937 15 | 31,701 | 22,679 58 |
| November | 139,077 | 136,766 54 | 37,047 | 25,201 21 |
| December | 153,582 | 151,041 03 | 37,385 | 21,753 05 |
| Total | 1,716,726 | 1,493,761 80 | 315,641 | $214,461 75 |

# REVIEW OF COAL TRADE.

The year just ended has been one of the most remarkable in the history of the mining industry of the State, more mines having been opened, more coal produced and more wages paid to employes. The total production, which reached 9,992,553 gross tons, shows a net increase of 1,229,356 tons, or nearly fourteen and one-fourth per cent. over 1902. This large increase is mainly attributable to the new mines opened, thirty-seven in number, yet as large as was the increase in production, it would have been very much greater had it not been for the shortage in railroad cars and lack of transportation facilities. This is especially true of the mines along the Southern Indiana Railroad. One mine on this road, viz: the Black Creek Mine, one of the largest producers in Greene County, fell short of the 1902 production something over thirty thousand tons. The Southern Indiana Railroad, however, was amply able to furnish both cars and transportation to the mines along its line had it not been for the numerous embargoes laid on the coal from their road by other railroads on which they were dependent for an outlet. To the general public, it would seem that the fault for this condition of affairs, attached to the railroads, yet, before placing the blame, it would be well to recall the following factors which should be taken into consideration, viz: the number of new mines that have been opened within the year, the number of railroad cars required to operate a fully developed mine, at say two-thirds time, and the interval from date of shipment of loaded cars and the returning of them to the mine, as well as the excessively heavy freight traffic of all kinds. A close railroad estimate gives thirteen days as the time required to ship a car of coal from the Linton field to Chicago and return the empty. Owing to transfers and other delays, it is presumed that the same would hold good for Indianapolis, while at some points in the gas belt it would require even a greater lapse of time. We must also bear in mind the additional fact that the majority of mines

opened recently to operate at full capacity, require from twenty to fifty cars per day. From this it will be seen that the new mines have been opened so rapidly that the consequent demand for railroad cars and motive power could not be furnished to meet the increased requirements.

The market price of coal, while not as high as it was at times in 1902, on the whole has been very good, ranging from $1.15 to $1.45 per ton, mine-run, and mines have undoubtedly been operated at a profit.

The aggregate wages paid in 1903 amounted to $9,149,572.12, an increase over 1902 of $2,070,659.00, or nearly twenty and nine-tenths per cent., while the total number of mine employes was 15,128, an increase of 1,989, or a fraction over fifteen and one-tenth per cent. over 1902. The average wages paid to mine employes in 1902 was five hundred and thirty-eight dollars and seventy-seven cents per employe. In 1903 it was six hundred and four dollars and fourteen cents, an increase over 1902 of sixty-five dollars and thirty-seven cents per mine employe.

Considering the time lost at the different mines the above figures speak well as to the condition of miners and others employed about the mines.

## NEW INVESTMENTS.

New investments within the year embrace mainly the opening of new mines, as reported before, thirty-seven in number, nearly all of which are equipped with up-to-date machinery, and will be classed among the largest producers.

## IMPROVEMENTS, AND CHANGES IN OWNERSHIP OF MINING PROPERTIES.

One hundred and sixty-eight thousand seventy-one dollars and ninety-six cents was reported to this office as having been spent on improvements of various kinds at Indiana mines, during the year 1903. Owing to the large increase of new mines, and the fact that the purpose for which the money was used was not always reported, it is presumed that a part of that sum was expended in equipping the new mines.

The following will show the changes in ownership and some of the most important improvements that have been made:

The Rebstock, a new block coal mine, in Clay County, was opened during the summer by the I. McIntosh Coal Company, changed ownership in November, and is now owned and operated by the Crawford Coal Company, who classes it as their No. 9 Mine.

The Rob Roy, also a block mine, located near Brazil, owned by the Andrews Coal and Mining Company, was purchased during the summer by the United Coal Company, who operated it a short time before abandoning.

The Otter Creek Coal Company have equipped their Mary Mine, in Parke County, with six electric chain machines.

The Petersburg Mine, in Pike County, owned by the J. Wooley Coal Company, of Evansville, was purchased during the month of June by the Muncie Coal and Mining Company. They have made extensive improvements with a view of increasing the capacity of the mine.

The S. H. Wulfman Coal Company, Pike County, have expended several thousand dollars in improving their Hartwell Mine, building a new tipple, equipped with shaker screens, installing electric motor haulage, which should give the mine a capacity equal to any mine in the southern part of the State.

The Rainbow Coal and Mining Company, Sullivan County, made some very extensive improvements at their Caledona Mine, equipping the hoisting shaft, remodeling the tipple, head frame, etc. They equipped the mine with electric mining machines and motor haulage, in addition to having sunk a new air shaft at the head of the workings, equipping it with a high-speed electric fan, from which excellent results have been obtained in the way of ventilation.

The Mildred Mine, in Sullivan County, is a new mine opened late in the fall by the Busron Coal Company. The J. Wooley Coal Company purchased this mine about the time the mine was completed and ready to ship coal.

The Brazil Mining Company and the Miami Coal Company, in Vigo County, formed a consolidation in November, and are now operating under the name of the latter company.

The Big Four Mine, Warrick County, located at Boonville, and the DeForest Mine, located at DeForest, both of which were formerly ventilated by furnace, have been equipped with fans, and in both instances excellent results have been obtained.

The Victoria Mine, located near Linton, Greene County, formerly owned by the Victoria Coal Company, was purchased early in the year by L. T. Dickason. This mine is operated under the original name.

The Island Coal Company, Greene County, have replaced the rope haulage in their No. 2 Mine, with electric motor haulage.

The Greene Valley Coal Company, Greene County, have installed a box car loader at their Greene Valley Mine, which proved of great value during the busy season when cars were scarce.

The Lattas Creek Coal Company, Greene County, and the Northwest Coal Company, have installed box car loaders.

The Lynn Coal Company, Knox County, was reorganized during the year, and their mine, which was formerly operated as a wagon mine, supplying the town of Bicknell and the adjacent country, now has a mine switch from the main line of the I. & V. Railroad. The mine has also been thoroughly equipped with up-to-date machinery, including shaker screens. At present it has a capacity of about five hundred tons per day, employing seventy-five miners.

O'Cara King & Company purchased the Lyford Mine, in Parke County, in April. The Wabash Valley Coal Company formerly owned this mine. The present Company equipped the mine with electric chain mining machines and other modern improvements.

## NEW MINES.

Thirty-four bituminous and three block coal mines have gone into operation within the past year, distributed in the different counties as follows:

Clay County, six; Daviess County, two; Fountain County, one; Greene County, six; Knox County, one; Parke County, three; Sullivan County, ten; Vermillion County, two; Vigo County, five, and Warrick County, one. Twenty-three of these, as shown by the following table, are hand or pick mines, while of the remaining fourteen there are three compressed air puncher ma-

chines, and eleven electric chain machine mines, which with few exceptions are equipped with the latest improved mining machinery of all kinds, such as self-dumping cages, shaker screens, box car loaders, first motion hoisting engines, etc., incident to handling a large output of coal and preparing it to suit the various market demands.

In the following table will be found the names of the companies owning and operating these new mines, the names of the mines, the railroad on which they are located, the geological number and thickness of coal seams, the depth and size of shaft, the kind of mines, the kind of machines used, when mines were commenced and when first shipment of coal was made.

# TABLE OF NEW MINES.

## BLOCK MINES.

### CLAY COUNTY.

| COMPANY. | MINE. | Railroad. | Geological Number of Seam. | Thickness of Seam. | Depth of Shaft. | Size of Shaft. | Machine or Pick Mine. | Kind of Machine. | Beginning of Operation | First Shipment. |
|---|---|---|---|---|---|---|---|---|---|---|
| Continental Clay Works | Continental | C. & E. I. | III | 4′ | 65 | 8 x 20 | Pick | | 10-1, '02 | 7, '03 |
| Crawford Coal Company | Rebstock | C. & E. I. | III | 3′ 3″ | 85 | 7 x 14 | Pick | | 7, '03 | 11-21, '03 |
| Brazil Block Coal No. 7 | Brazil Block No. 7 | Vandalia | III | 4′ | 105 | 8 x 17 | Pick | | '02 | 2-1, '03 |

## BITUMINOUS MINES.

### CLAY COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Indiana Bituminous Coal Co | Fair View | Vandalia | VI | 7′ 6″ | 80 | 9 x 19 | Pick | | 8-1, '03 | 10-1, '03 |
| Lewis Coal and Mining Co | Lewis | Southern Ind. | V | 9′ | 77 | 8 x 15 | Pick | | 8-26, '03 | 7-1, '03 |
| Zellar McClellan & Company | Cloverland No. 2 | Vandalia | VI | 7′ | 90 | 8 x 21 | Pick | | 8-26, '03 | 10, '03 |

### DAVIESS COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Washington-Wheatland Coal Co | Wheatland | B. & O. S. W. | IV | 5′ | 100 | 8 x 17 | Pick | | 11-1, '02 | 7-20, '03 |
| Mandabach Bros | Mandabach | E. & I | V | 6′ | 56 | 6 x 12 | Pick | | | 7-1, '03 |

### FOUNTAIN COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Silverwood Coal Co | Silverwood | Cloverleaf | V | | | | Pick | | | 12-1, '03 |

## GREENE COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| .... | Hoosier No. 2 | Southern Ind. | V | 7′ | 46 | 9 x 17 | Machine | Elec. chain | .... | 11, '03 |
| Co | North Western No. 3 | Southern Ind. | IV | 5′ | 75 | 9 x 16 | Machine. | Elec. chain. | 8, '02 | 2, '03 |
| Co | Atlas No. 2 | I. & V. | IV | 5′ | 128 | 9 x 16 | Machine. | Elec chain. | 12, '02 | 8, '03 |
| .. | Island No. 5 | Southern Ind. | IV | 5′ | 56 | 8 x 19 | Pick | .... | 7, '03 | 8, '03 |
| .... | Letsinger | Southern Ind. | III | 7′ 6″ | .... | .... | Machine. | Comp. air | '02 | 2, '03 |
| .... | Twin | I. & V. | IV | .... | .... | .... | Machine. | .... | .... | 10, '03 |

## KNOX COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Enterprise | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |

## PARKE COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Parke County Coal Co. | Parke No. 11 | T. H. & L. | VI | 6′ 6″ | 102 | 8 x 16 | Machine. | Comp. air | 7-1, '03 | 1, '03 |
| Minshall Vein Coal Co. | Minshall No. 2 | T. H. & L., Vandalia, Logansport | V | 5′ | 107 | 9 x 18 | Pick | .... | .... | 11-20, '03 |
| Raccoon Valley Coal Co | Brier Hill | T. H. & L. | VI | 5′ | Drift | Compa | ny bought | mine in Dec | 1902. | 1, '03 |
| Mecca Coal and Mining Co | Mecca No. 4 | .... | .... | .... | .... | .... | .... | .... | .... | .... |

## SULLIVAN COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Mammoth Vein Coal Co | Mammoth Vein | E. & T. H | VI | 6′ | 173 | 9 x 15 | Machine. | Elec. chain | Spring, '03 | 12, '03 |
| Little Giant Coal Co | Little Giant | Monon | VI | 5′ 6″ | .. | 9 x 16 | Machine. | Elec. chain. | Fall, '02 | 7, '03 |
| Indiana Hocking Coal Co | Lablanch | R. & T. H | VII<br>VI | 4′<br>5′ 6″ | 221 | 9 x 19 | Machine | Elec. chain | 8, '03 | 12, '03 |
| Bruilettes Creek Coal Co | Bruilette's Cr'k No 6 | E. & T. H | VII | 5′ 6″ | 80 | 9 x 16 | Machine. | Elec. chain. | Fall, '03 | 12, '03 |
| .... | Mildred. | E. & T. H | VI | 5′ | 144 | 8 x 17 | Machine. | Elec. chain. | 5-10, '03 | 12, '03 |
| .... | Island No. 4 | I. & V. | IV | 5′ | 260 | 9 x 17 | Pick | .... | 3, '03 | 11, '03 |
| .... | Cummins | E. & T. H | VII | 5′ | Slope | .... | Machine. | Comp. air | Fall, '02 | 8, '03 |
| .... | Citizens. | Local | VI | 5′ | 165 | 8 x 16 | Pick | .... | 6, '03 | 10, '03 |
| .... | Superior No. 1 | E. & T. H | VII | 5′ 6″ | 112 | 9 x 18 | Pick | .... | 4, '03 | 11, '03 |
| Co | St. Clair | Southern Ind | VI | 5′ 6″ | 197 | 9 x 18 | Machine. | Electric | 6, '03 | 11, '03 |

# TABLE OF NEW MINES—Continued.

## BITUMINOUS MINES—Continued.

### VERMILLION COUNTY.

| COMPANY. | MINE. | Railroad. | Geological Number of Seam. | Thickness of Seam. | Depth of Shaft. | Size of Shaft. | Machine or Pick Mine. | Kind of Machine. | Beginning of Operation. | First Shipment. |
|---|---|---|---|---|---|---|---|---|---|---|
| Clinton Coal Company | Crown Hill No. 2 | C. & E. I. | VII | 5′ | 151 | 8 x 16 | Pick | | 5-1, '03 | 7-14, '03 |
| Brazil Block Coal Co | Rhoades | C. & E. I. | VII | 5′ 6″ | 100 | 8 x 17 | Pick | | Fall, '03 | 10-1, '03 |

### VIGO COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Miami Coal Co | Miami No. 2 | C. & E. I. | VI | 6′ 6″ | 50 | 8 x 16 | Pick | | Spring, '03 | 5-1, '03 |
| Deep Vein Coal Co | Deep Vein | Vandalia | VI | 6′ | 170 | 8 x 10 | Pick | | Spring, '03 | 9-1, '03 |
| Sugar Creek Coal Co | Sugar Creek | Vandalia | V | 6′ | 105 | 10 x 20 | Pick | | | 10-20, '03 |
| Lost Creek Coal Co | Lost Creek No. 1 | Vandalia | VI | 6′ | 120 | 9 x 16 | Pick | | 12, '02 | 9-1, '03 |

### WARRICK COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| T. D. Scales Coal Co. | Scales | Southern Ind | V | 7′ | 30 | 9 x 18 | Machine | Comp. air | Fall, '02 | 6-1, '03 |

NOTE.—There are two seams opened at the Twin Mine, viz., No. IV and No. V. No. IV is found at a depth of one hundred and fifty feet from the surface, carrying four feet in thickness. No. V lies at a depth of fifty-six feet from the surface, six feet thick, and is opened by a double shaft nine by thirty feet in size, the coal from both being hoisted from the same opening. The steam boilers, hoisting engines, dynamos and other machinery are concentrated into one power plant, thereby causing a considerable saving in steam and electric power, labor and fuel, which are necessary to generate such power and operate the machinery, as well as labor in many other departments in and about a mine. There is also a saving in mine buildings, as one blacksmith shop, one carpenter shop, one powder magazine, one fan and fan house, one mule barn, etc., will answer for the two mines.

In addition to the above, the No. IV mine has been equipped with a system of light motor haulage with which it is the purpose to gather the coal direct from the working faces. If successful (there being no good reason why it should not) this will result in an immense saving in the cost of brushing the roadways for height, which on account of the thinness of the coal seam, would be necessary if mule haulage were used.

The sinking and equipping of a mine in this manner, with the existing conditions, is the first attempt of the kind in the State, and results are being very closely watched by those interested in mines and mining. The success of the motor haulage is especially interesting to the general public, as a problem will then perhaps have been solved which will place some of our thin coal seams on a better competitive basis with the thicker ones, and in many instances making it possible to operate mines at a profit in certain coal fields which are now considered worthless on account of such conditions as referred to above, thereby enhancing the value of such lands, also adding greatly to the value of workable coal in the State, the latter being a factor which at some future day will become an important one in connection with our fuel supply.

# ABANDONED MINES.

*Table Showing Names of Mines, Company and Month of Abandonment.*

| Name of Mine. | Company. | County. | Month. |
|---|---|---|---|
| Brazil Block No. 11 | Brazil Block Coal Company | Clay | November. |
| Gart No. 5 | Brazil Block Coal Company | Clay | March. |
| Briar Hill | Clay City Coal Company | Clay | March. |
| Eureka No. 2 | Eureka Block Coal Company | Clay | January. |
| Pratt | Coal Bluff Mining Company | Clay | July. |
| Silverwood No. 3 | Indiana Bituminous Coal Company | Clay | October. |
| Silverwood No. 2 | Indiana Bituminous Coal Company | Fountain | February. |
| Bruilette's Creek No. 4 | Bruilette's Creek Coal Company | Vermillion | January. |
| Brick Works | Terre Haute Brick and Pipe Co | Vigo | June. |
| Nickel Plate | Brazil Mining Company | Vigo | September. |
| Ray | Seeleyville Mining Company | Vigo | February. |

Labor conditions, as a whole, have been very satisfactory during the year, there having been but few strikes, other than local, and these usually lasted but a few days. The strike at the Black Creek Mine, during the summer, originating over the discharge of a driver for beating a mule, was of longer duration than any other. It was in effect some three weeks. We give herewith the Terre Haute and Brazil Agreements.

## TERRE HAUTE AGREEMENT.

April 1, 1903, to March 31, 1904.

Pursuant to an agreement made between the Coal Operators and United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, Ind., February 7, 1903, the price of mining for bituminous coal in the State of Indiana shall be 90 cents per ton of 2,000 pounds for screened lump coal, made over a standard screen, and 55 cents per ton of 2,000 pounds for run-of-mine. That further details in scale of prices for pick and machine mining in the State of Indiana for one year, beginning April 1, 1903, shall be as follows:

The standard height of coal in Indiana shall be 3 feet 6 inches, excepting in mines already opened, where the standard height shall be 3 feet 3 inches. All coal less than 3 feet 3 inches in thickness and over 2 feet 9 inches, the price shall be 98 cents per ton for screened lump coal, and 64 cents per ton for mine-run coal. All coal less than 2 feet 9 inches and down to 2 feet 6 inches, the price shall be 106 cents per ton for screened lump coal and 65 cents per ton for mine-run coal.

Narrow entries 7 to 9 feet wide, $1.86¾ per yard.

Wide entries 12 feet wide, $1.16½ per yard.

Wide entries shall not be more than 13 feet nor less than 11 feet. In the event of a 10 or 11 feet entry being demanded by the operator, narrow entry prices shall be paid, if 14, 15, 16 or 17 feet entries are demanded the wide price shall be paid.

The right of the operators to drive an 18 foot room when necessary shall not be questioned.

### Break Throughs.

Break throughs between entries shall be paid for at entry prices.

Break throughs between rooms, when sheared or blocked, shall be paid for at entry prices, but no break throughs shall be driven without consent of the operators. Nothing herein shall interfere with the law governing break throughs.

### Room Turning.

Room turning ..... $4 50

Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by the operator. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, the price shall be ⅝ of regular price, or $2.81¼.

### Machine Mining.

In entries 7 to 9 feet wide..... $1 34

In entries 12 feet wide, ⅝ of price for narrow entries, or 83¼. Narrow work after punching machines shall be sheared when demanded by the operator. Narrow work after the chain machine must be done in a workmanlike manner.

### Break Throughs.

Break throughs between entries, same as entry prices. Break throughs between rooms shall be paid for at same price when similarly driven.

### Room Turning—$3.37½.

Room necks to be driven 12 feet in and widened at an angle of 45 degrees when so desired by the operators. Any distance in excess of above shall be paid for proportionately, but no room neck shall exceed 15 feet. When room necks are driven 12 feet wide, price shall be ⅝ of regular price, or $2.10.

### Day Work for Punching Machine.

Machine work, when paid for by the day, shall be for:

Machine runner ..... $3 17
Helper ..... 2 56

### Day Work, Chain or Cutter Bar Machine.

When paid for by the day, shall be for:

Machine runner ..... $3 01
Helper .....3 01

Day work by machines shall apply only to opening new mines and defective work, such as horsebacks, etc.

### Price Per Ton for Machine Mining for Punching Machine.

Vandalia track and north thereof:

Screened lump.—Runner, 11½ cents; helper, 10½ cents; loading, shooting and timbering, 50 cents. Total, 72 cents.

Run-of-Mine.—Runner, 7½ cents; helper, 7 cents; loading, shooting and timbering, 30½ cents. Total, 45 cents.

South of Vandalia track:

Screened Lump.—Runner, 10½ cents; helper, 9 and 3-10 cents; loading, shooting and timbering, 52 and 2-10 cents. Total, 72 cents.

Run-of-Mine.—Runner, 6 and 6-10 cents; helper, 6 and 6-10 cents; loading, shooting and timbering, 32 and 3-10 cents. Total, 45 cents.

### For Chain Machine

Screened Lump.—Runner, 6¼ cents; helper, 6¼ cents; loading, shooting and timbering, 56 cents. Total, 68½ cents.

Run-of-Mine.—Runner, 4 cents; helper, 4 cents; loading, shooting and timbering, 34½ cents. Total, 42½ cents.

Machine shovels shall be furnished by the operators, but when replaced the old shovels must be returned, and in case of careless breaking or destruction, the helper shall pay for the shovel so destroyed.

### Blacksmithing.

Price of blacksmithing shall be 1¼ cents on the dollar.

Sharpening shall be done in a workmanlike manner, and men shall not have to wait for their tools.

### Day Labor.

Inside day labor shall not be less than $2.56 per day of eight hours, when men are employed. And for outside day labor on and north of the B. & O. S. W., the minimum price shall be $2.02½ per day.

South of the B. & O. S. W., the price shall be 20¼ cents per hour.

All outside day laborers working at the mines, excepting weighmasters, flat trimmer and dumper, who shall be regarded strictly as company men, shall be recognized as members of the United Mine Workers of America, and present conditions and hours of labor shall prevail during the existence of this contract; and, provided further, that in emergencies or in the absence of any regular employe the right of the operator to employ men not members of the United Mine Workers of America for outside day labor, shall not be questioned.

Any and all flat trimmers shall dock for dirty coal.

### Dead Work.

1. It is agreed that the companies shall have the working places as dry as local conditions will permit, and said working places shall be in working condition at time of starting work in the morning. If any companies shall fail to have said working places dry or reasonably so one hour after starting time two successive days, the company shall, if said failure is traceable to neglect or carelessness of the company's agent,

give miner or miners so affected other work or pay him or them for time so lost.

2. The question of slate in or over the coal shall be and is regarded a local question to be taken up and adjusted by the methods provided in the annual Terre Haute agreement for the settlement of disputes. Provided, however, that established usages and prevailing conditions shall not be changed except in new mines where they have not been considered and adjusted.

3. Where bottom coal is excessively hard to take up, the operator shall have the option. If he demands that it be taken up he shall pay extra therefor. Provided, that where coal so left shall exceed 4 inches in thickness it shall be taken up by the loaders and paid for by the machine men, but this shall not apply when caused by sulphur boulders, rock or any unusual condition. And whenever there shall arise a dispute between any loader and boss, or committee and boss, as to whether the bottom coal in any room is "excessively hard," the company interested shall select a man who shall take up one-third of such bottom coal, and if by such test it requires more than forty minutes to take up all the bottom coal in such room, then the loader shall be paid at the rate of 30 cents per hour for such time so required in excess of forty minutes. This is to apply to the No. 4 vein of Linton coal.

### General.

1. When the coal is paid for mine-run, it shall be mined in as good condition as when paid for on the screened lump basis, and, when loaded on the miner's car, it shall, as nearly as possible, be free from slate, bone coal, or other impurities, and, if it can be shown that any miner persistently violates the letter or spirit of this clause, he shall be discharged. Persistently, as used in this clause, means three cars the first week and two cars in any succeeding week. Nor shall he load an undue proportion of fine coal in any one car, but shall see that the fine coal is mixed with the large coal in such a way as to make a fair quality of mine-run coal. This provision for cleaning coal and penalty for failure also applies to screened lump coal.

2. The semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme courts of Indiana and of the United States.

3. The time for beginning work in the morning and the length of intermission at noon shall be considered a local question.

4. That the above scale is based upon an eight-hour work day; that it is definitely understood that this shall mean eight hours' work at the face, exclusive of the noon time, six days in the week or 48 hours in the week, and that no local ruling shall in any way deviate from this agreement, or impose conditions affecting the same, but any class of day labor may be paid at the option of the operator for the number of hours and fraction thereof actually worked at the hour rate, based on one-eighth of the scale rate per day. Provided, that when men go into the mine in the morning, they shall be entitled to two hours' pay whether the mine works or not, excepting in event of a mine being closed down by action of any member or members of the U. M. W. of A., the two hours' pay shall be forfeited.

## Regarding Drivers.

They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor, their work beginning when they reach the change at which they receive empty cars, but in no case shall a driver's time be docked while he is waiting for such cars at the point named.

5. Inside day work may be done upon idle days, and in case of emergency on overtime.

6. It is agreed that if any difference arises between the operators and the miners at any time, a settlement shall be arrived at without stopping the work. If the parties immediately affected can not reach an agreement themselves, the question shall be referred without delay to a board of arbitration consisting of two operators, selected by the operator interested, and two miners, selected by the local union of the United Mine Workers of America involved. In the event of these four being unable to reach a decision, they shall select a fifth man, and the decision of the board so constituted shall be final, but no miner or operator directly interested in the differences shall be a member of such board.

Nothing in the above shall be construed as excluding officers of the miners' or operators' associations, nor mine superintendents.

7. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines, except as hereinafter set forth in Article No. 16. In case they fail to agree, they shall proceed to adjust the trouble by the selection of an arbitration board as provided in Article 6 of this agreement. The mine committee shall have no other authority, nor exercise any other control, nor in any way interfere with the operation of the mine, and, for violation of this agreement, the committee or any member thereof or mine boss or superintendent shall be discharged.

8. That under no circumstances will the operator recognize or treat with a mine committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

9. The operator shall have the privilege of working a night shift for cutting coal with machine. All men so employed shall be paid 28 cents extra for each hours' work at night, in addition to the scale price per ton.

10. Work on driving entries and drawing pillars may be by double shift, at the option of the operator.

11. This contract shall in no case be set aside because of any rules of any local union of the U. M. W. of A. Nor shall there be any rules made controlling or affecting the operations of the mines nor shall any change be made in accepted rules without the operators and miners first consulting and agreeing thereto.

12. Coal may be dumped as slowly as the operator may find necessary to thoroughly screen it, even if the car is brought to a stop, but it shall not be dumped in such a way as to throw the coal over the car door or unnecessarily break it.

13. Any miner knowing his place to be unsafe, shall protect same without delay and shall go into the mine for that purpose outside of regular hours and on idle days.

14. No restrictions shall be placed on the amount of coal which machines may mine, nor on the number of cars that any miner may load in any specified time.

Men shall work double in wide entries at option of operator in developing the mine or for running entries for purpose of increasing production.

Enough extra loaders shall be employed in each mine so that the full complement of loaders agreed upon to follow each machine shall be at work every day that the mine hoists coal.

Where three places are now given to two loaders the custom shall continue.

No more than three places for two men nor two places for one man shall be allowed. In mines where the coal averages 6 feet high or over, rooms 30 feet wide or over equipped with two tracks shall be considered double places, and two loaders may be limited to two such places.

In Sullivan county where men work double in two rooms 25 to 30 feet wide with track up the center, the custom shall continue.

Whenever a new mine is opened it shall be governed by the same rules existing in other contiguous mines in the same vein of coal.

15. The price of powder per keg shall be $1.75. The miners agree to purchase the powder from their operators, provided, it is furnished of standard grade and quality, that to be determined by the operators and expert miners jointly where there is a difference.

16. Engineers shall be paid the present rate of wages, thus 12½ per cent. advance. Eight hours shall constitute a day's work. But the engineers shall outside of regular hours, hoist and lower the men, and in addition shall perform all the duties which necessarily and usually pertain and belong to an engineer's position, and shall not receive any extra pay therefor. It is agreed further that no hoisting engineer shall be subjected to the interference or dictates of the mine committee nor the local unions, but all the differences between the engineer and his employer shall be adjusted by the officers of the U. M. W. of A. and employer interested.

17. The prices now paid firemen and blacksmiths, together with present condition of employment and hours of labor, shall continue during the existence of this contract, plus 12½ per cent. advance.

18. It is further agreed that the operators shall offer no objection to the check-off for the check-weighman and for dues for the U. M. W. of A., provided that no check-off shall be made against any person until he shall have first given his consent in writing to his employer. This applies to all day work as well as miners.

### Shot Firers.

Present conditions as to shot firers shall continue until a commission composed of one miner, to be selected by the United Mine Workers of America of District No. 11, one operator, to be selected by the Bitumin-

ous Coal Operators' Association of Indiana, and Professor Robert Thurston of Cornell College, an expert engineer, shall be appointed.

Such commission shall, as soon as possible, examine the so-called dangerous pick mines in the state of Indiana and decide whether or not it is necessary to employ shot firers in any of said mines on account of gas, dust or other causes beyond the control of either miners or operators. the present methods of mining not to be considered as being beyond control.

If a majority of such commission shall decide that it is necessary that shot firers be employed in any mine and shall sign a report to that effect, then shot firers may be employed by the miners in such mine, who shall pay them for their services, and such shot firers shall be wholly in the employ of the miners and in no manner whatever to be the agents, servants or employes of the owners, operators or managers of the mine.

The owner or operator of any mine where the commission decides that it is necessary that shot firers be employed and where they are so employed by the miners, shall pay to the local union an amount of money equivalent to one-fourth cent (¼ cent) per ton of mine-run or two-fifths (⅖ cents) per ton of screened lump of the output of said mine.

It being agreed and understood that such payment to the local union shall not directly or indirectly be considered as or construed to be a payment by the owner or operator of any part or portion of the services rendered by shot firers for the miners.

It being further expressly agreed and understood that in any mine where shot firers are employed that the relation of master and servant shall exist wholly between the miners and the shot firers and that such relation shall not obtain as between the owner or operator of the mine and the shot firers.

The expenses of such commission shall be borne equally by the United Mine Workers of America of District No. 11, and the Bituminous Coal Operators' Association of Indiana, except that the Operators' Association shall alone bear the expenses occasioned by the appointment and services of the expert engineer.

In behalf of the Indiana Bituminous Coal Operators' Association:

J. C. KOLSEM, President.

P. H. PENNA, Secretary.

United Mine Workers of America, District No. 11:

GEO. HARGROVE, President.

J. H. KENNEDY, Secretary.

## BRAZIL AGREEMENT.

### CONTRACT.

### Pick Mining Scale for 1903.

Contract between the Operators, Miners and Day Laborers of the Brazil Block Coal District from April 1st, 1903, to April 1st, 1904:

1. Entered into this first day of April, 1903, between the Operators' Scale Committee of the Block Coal District and the Executive Board of the United Mine Workers of America, representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and United Mine Workers of America, of Indiana, Illinois, Ohio and Pennsylvania, made at Indianapolis, Ind., February 7, 1903.

3. The price for mining screened block coal in the Block Coal District of Indiana shall be one ($1) dollar per ton of 2,000 lbs., it being understood also that the price for digging unscreened coal shall be an equivalent of the price paid for screened coal.

4. That further details in the scale of prices for pick mining in the Block Coal district shall be as follows:

5. The payment for low coal shall be upon the following scale:

6. For all coal two feet ten inches and under three feet one inch, one dollar and five ($1.05) cents.

7. For all coal under two feet ten inches one dollar and ten cents ($1.10).

8. The price of yardage shall be as follows:

| | |
|---|---|
| Single yardage in coal 3 ft. 1 in. or over | $1 00 |
| Double yardage in coal 3 ft. 1 in. or over | 2 00 |
| Gob entries in coal 3 ft. 1 in. or over | 1 50 |
| Gob entries in coal 3 ft. 1 in. or over, without brushing | 50 |
| Single yardage in coal 2 ft. 10 in. and under 3 ft. 1 in | 1 05 |
| Double yardage in coal 2 ft. 10 in. and under 3 ft. 1 in | 2 10 |
| Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in | 1 57½ |
| Gob entries in coal 2 ft. 10 in. and under 3 ft. 1 in. without brushing | 52½ |
| Single yardage in coal below 2 ft. 10 in | 1 10 |
| Double yardage in coal below 2 ft. 10 in | 2 20 |
| Gob entries in coal below 2 ft. 10 in | 1 65 |
| Gob entries in coal below 2 ft. 10 in. without brushing | 55 |

All entries to be driven when required by the operator, 5½ feet in the clear in height, and the miners agree to gob the dirt, when he is not required to take it more than the distance of six rooms back from the last break through, and when the dirt is hauled by a mule, then the miners agree to unload the same at a distance of not more than eight rooms back from the last break through from the face of the entry. This agreement shall apply to all the block coal mines in the Block Coal District, with the exception of the Present No. 1 and No. 2 Superior mines of the Zeller & McClellan Company, and in these two mines the same conditions shall continue as were in force during the year just ending, viz., The miners shall continue to gob the break throughs. Twenty-five

cents per yard shall be paid extra for all double yardage when the same is worked double shift, and 12½ cents per yard for all single yardage when same is worked double shift. Work on driving entries and drawing pillars may be double shift at the option of the operator.

It is further agreed that the McIntosh & Co. mine will submit to an investigation relative to the time that the companies commenced gobbing the dirt, and that said company will abide by the decision of the joint board relative to the operators' right to have the dirt gobbed at these mines.

9. Inside day scale:

| | |
|---|---|
| Track layers | $2 56 |
| Track layers' helpers | 2 56 |
| Trappers | 1 13 |
| Bottom cagers | 5 26 |
| Drivers | 2 56 |
| Trip riders | 2 56 |
| Water haulers | 2 56 |
| Timbermen, where such are employed | 2 56 |
| Pipe men, for compressed air plants | 2 50 |
| All other inside day labor | 2 56 |
| Blacksmiths | 2 85 |

All outside day labor shall receive 12½ per cent. advance.

10. The firemen and night pumpers shall be paid at the rate of twenty-four (24) cents per hour for their labor. The above wage is based on an eight (8) hour work day, but in the event the operator desires it, the firemen and night pumpers are to work overtime to the extent of not more than two hours in any one day or shift.

However, it is understood that in the event of an emergency, the firemen and night pumpers will not limit their time but continue working until such emergency is past.

11. Where a miner is working a deficient place, and is being paid by the day, his pay shall be $2.60 per day, and if he uses his own tools during such time, he shall be paid 10 cents per day for the use of same. The operator shall have the option of furnishing the tools for any such work.

12. The price of blacksmithing shall be 1½ cents on the dollar.

13. Semi-monthly pay shall continue until the constitutionality of the law providing for weekly pay shall have been passed upon by the Supreme courts of Indiana and of the United States.

14. The miner shall not be compelled to load his coal more than six feet from the face at beginning time.

15. Inside day work may be done upon idle days, and in case of emergency on overtime.

16. The hour to begin work in the morning shall be seven (7) a. m., with thirty minutes' stop for dinner, and begin shooting at 3:30 o'clock p. m., from April 1, 1903, to October 1, 1903, and from October 1, 1903, to April 1, 1904, the mines shall start at seven-thirty a. m., with thirty minutes' stop for dinner, and begin shooting at 4:00 p. m., and that no shooting shall be done at the mine except by mutual consent between the bank boss and the bank committee, and in the event that the mine is to work

a half day it shall be the duty of the mine boss to notify the bank committee of the fact.

17. That eight hours a day means eight hours' work in the mine at the usual working places for all classes of inside workmen. This shall be exclusive of the time required in reaching said working places in the morning and departing from the same at night.

18. The miners hereby agree to do all the propping in their rooms, except setting of props required to break the bottom in shooting the same, and if any props are loosened or displaced, thereby endangering the safety of the workmen, the miners agree to reset the same.

19. It is also agreed on the part of the operators not to require the miners to put down their own road, and bottom shooters may lay the road in the rooms when required.

20. Also to give each miner as near as possible an equal turn of cars, and not to allow any day hands to load coal on idle days.

21. No miner shall be discharged or discriminated against because of his refusal to do work by the day when called upon by the pit boss.

22. It is also agreed not to require miners to load or clean falls unless they are caused by some fault of the miner not properly timbering his working place, or his having shot or otherwise caused his timber to become insecure, in which case it will be the duty of the miner to put his place in good order again.

23. It is further agreed that if any differences arise between the operator and miner at any pit, settlement shall be arrived at without stopping of work. If the parties immediately affected can not reach an adjustment between themselves, the question shall be referred to the Executive Board of the United Mine Workers of America, representing District No. 8, and an equal number of operators, whose actions shall be final, but no miner nor operator interested in the differences shall be a member of said committee.

24. The duties of the mine committee shall be confined to the adjustment of disputes between the mine boss or superintendent and any of the members of the United Mine Workers of America, working in and around the mines.

25. Regarding drivers: They shall take their mules to and from the stables, and the time required in so doing shall not include any part of the day's labor. Their work beginning when they reach the parting at which they receive empty cars, and in no case shall the driver's time be docked while he is waiting for said cars at the point named, but when the men go into the mine in the morning they shall be entitled to two hours' pay, whether or not the mine works the two full hours, but after the first two hours, the men shall be paid for every hour thereafter by the hour, or for each hour's work or fractional part thereof. If for any reason the regular routine of work can not be furnished inside labor for a portion of the first two hours, the operators may furnish other than the regular labor for the unexpired time.

26. That under no circumstances will the operators recognize or treat with a mine committee or any representative of the United Mine Workers of America, during the suspension of work, contrary to this agreement.

27. The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area,

of uniform size, one and one-quarter (1¼) inches between the bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

28. It is hereby further agreed that track layers may begin work on top before the usual time of hoisting coal in getting track material ready to send down on the cage, and that the time required in doing so shall be a part of the eight hours' work.

29. In case of emergency work, the mine boss shall consult with the mine committee, and if they approve of the work being done on overtime, the men engaged thereon shall not be required to lay off until their time is equalized with the others working in the said mine.

30. The Crawford Coal Company in their mines at Center Point may continue to do the brushing in the entries where the coal is 3 feet 1 inch and under in thickness.

31. This contract is entered into in good faith by both parties, and there is to be no deviation from it by the operators, miners, laborers or any local union.

Committee on behalf of the Operators for the Block Coal District:

JAS. H. McCLELLAND,
WM. M. ZELLER,
W. E. EPPERT,
JAMES T. ANDREW,
A. H. ZIMMERMAN.

Executive Committee District No. 8, United Mine Workers of America, for Block Coal Miners:

JAMES CANTWELL,
WILLIAM HUSTON,
WM. TREAGER,
WILLIAM WILSON.

## CONTRACT.

### Machine Mining Scale for 1903.

Contract between the Machine Operators of the Block Coal District and the Executive Board District No. 8, United Mine Workers of America, governing prices and conditions of mining in Machine Mines Block Coal District:

1. Entered into this first day of April, 1903, between the Operators' Machine Mines of the Block Coal District, and the Executive Board of the United Mine Workers of America representing District No. 8.

2. Pursuant to a contract made between the Coal Operators and the United Mine Workers of America of Illinois, Indiana, Ohio and Pennsylvania, made at Indianapolis, Ind., February 7th, 1903.

3. The price for loading, shooting, timbering, taking care of all draw slate that is four (4) inches and under in thickness, in rooms and entries, shall be fifty-three and one-half (53½) cents per ton.

Price for entry driving, 6 to 9 ft. wide, fifty-three and one-half (53½) cents per yard.

Price for entry driving, 9 to 12 ft. wide, thirty-two and one-half (32½) cents per yard.

The loader agrees to keep the bug dust and draw slate back 14 ft. from the working face.

All entries more than 12 feet in width shall be paid same as rooms.

Machine Runners and Helpers to be paid twenty-five (25) cents per ton, and when working by the day, machine runners to be paid $3.03¾ per day. Helpers, $2.70 per day. Motormen receive 12½ per cent. increase on present wages.

Entry driving, 6 to 9 ft. wide, Machine Runner to be paid 25 cents per yard.

Entry driving, 9 to 12 ft. wide, Machine Runner to be paid 16 cents per yard.

It is further agreed that where there is not sufficient room to gob the bug dust and draw slate, the loader will load it in the bank cars and the company will unload it.

It is understood that there shall be nothing paid for room turning or low coal, and there shall be nothing charged for blacksmithing.

There shall be no discrimination against any employes.

That the system of loading coal in machine mines be on the following basis, to wit:

1. That one man shall have the right to two places where he can take care of same.

2. That two men shall have the right to three places where they can take care of same.

3. All others one place.

When a man is off work more than one day, the mine boss shall have the right to put a man in the places if it is necessary, providing the man leaves the places in the same condition as near as possible as he found them.

The Block Coal District of Indiana may continue the use of the diamond bar screen, the screen to be seventy-two (72) feet superficial area, of uniform size, one and one-quarter (1¼) inches between bars, free from obstructions, and that such screen shall rest upon a sufficient number of bearings to hold the bars in proper position.

This agreement to become a part of the agreement entered into on the 1st day of April, 1903, between the Operators' Scale Committee of the Block Coal District, and the Executive Board of the United Mine Workers of America, representing District No. 8.

On behalf of the Machine Operators of the Block Coal District:

BRAZIL BLOCK COAL CO.,
JAS. H. McCLELLAND, President.
DIAMOND BLOCK COAL CO.,
JAS. H. McCLELLAND, President.

On behalf of the Executive Board District No. 8,
United Mine Workers of America:

JAS. CANTWELL,
WILLIAM HUSTON,
WM. TREAGER,
WILLIAM WILSON,
HARRY WRIGHT,
Members M. E. B.

## CONTRACT

### BETWEEN THE NATIONAL BROTHERHOOD OF COAL HOISTING ENGINEERS AND OPERATORS OF DISTRICT NO. 8, SIGNED MARCH 21, 1903.

1. On and after April 1, 1903, until April 1, 1904, the scale of Hoisting Engineers throughout the Block Coal District, or District No. 8, shall be as follows: Where one Engineer is employed, the compensation shall be eighty-four dollars and thirty-seven cents ($84.37) per month. Where two Engineers are required, the first Engineer shall receive eighty-four dollars and thirty-seven cents ($84.37) per month, the second seventy-three dollars and twelve cents ($73.12) per month, and when they change week about seventy-eight dollars and seventy-five cents ($78.75) per month.

2. It is agreed on the part of the Engineers to be at their work in time to lower the men and mules, and remain a sufficient time after the regular working hour to hoist the men and mules from the mine. Also to keep up all repairs on the machinery, including pumps in the mine.

3. It is also mutually agreed that a licensed Engineer shall be employed at all times when steam is required at the throttle. Provided, however, that in all cases where the mine is not hoisting coal, or the machines are not operated, then, and in all such cases, the Engineers are required to do their own firing, it being understood that this provision does not apply to any case where the work of the mine may be stopped in the midst of any one shift. Nor does it cover any case where the fireman is required to assist in the washing or cleaning out the boilers on Sunday.

4. It is also fully understood and agreed upon the part of the Brotherhood of Hoisting Engineers that they will not under any circumstances allow affiliation with any other labor organization to interfere with or prevent their being on duty at any and all times required by the operators, and that they will not suspend work in sympathy with any other organization; and further that they will during the continuance of this contract at all times fully protect all the company's property under their care, and that they will operate fans and pumps, and lower and hoist such men or supplies as may be required to protect the company's property, and any and all coal that may be required to keep up the steam at the company's plant. But it is understood that the operators will not ask them during this period to hoist any coal produced by nonunion labor for sale on the market.

5. It is also agreed that only members of the National Brotherhood of Coal Hoisting Engineers shall be employed in the capacity of hoisting engineers during the continuance of this agreement, when such members, competent to fill the position, can be obtained.

6. No Engineer shall lay off or exchange shifts without the consent of the operators.

7. It is also agreed that in case of sickness or unexpected absence of the engineer any other engineer or engineers shall perform his duty; and if desired by them his wages for time so absent shall revert to the engineer performing such duty.

8. It is also agreed that in case of dispute or trouble arising between any Engineer and the Operator by whom he is employed, work shall not be suspended, but the grievance shall be taken up by the proper officials.

9. It is also agreed upon the part of the operators that they will enforce a rule forbidding the entering of the engine-room by loafers and disinterested parties and that they will have cards printed and placed in conspicuous places to this effect.

Signed and agreed to by Operators' Committee:

JAS. H. McCLELLAND.
WM. M. ZELLER,
A. H. ZIMMERMAN,
M. H. JOHNSON.

Engineers' Committee:

LUTHER PULLEN.
ALBERT HIXON.
T. E. JENKINS,
D. H. COLLIER,
W. C. BIGGINS.
FRANK YOCKUM.

# TABLE

*Showing by Counties the Name of Mine, Number of Tons Screened, Slack and Nut and Mine Run Coal, Total Tons of All Grades of Coal Produced, and the Distribution Thereof; the Production of Block and Bituminous Coal, Each Being Shown Separately, as is the Machine and Pick or Hand Mined Coal.*

## BLOCK COAL MACHINE MINES.

### CLAY COUNTY.

| NAME OF MINE. | Machine Mined. | | | | Pick Mined. | | | | Distribution. | | Wages Paid. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons of Screened Coal. | Tons of Slack and Nut. | Tons of Mine-Run. | Total Tons of all Kinds of Coal Produced. | Tons of Screened Coal. | Tons of Slack and Nut. | Tons of Mine-Run. | Total Tons of all Kinds of Coal Produced. | Indiana. | Other States. | To Miners. | To Inside Day Men. | To Outside Day Men. | Total Wages. |
| Brazil Block No. 1 | 10,079 | 2,015 | ..... | 12,094 | 12,764 | 2,555 | ..... | 15,319 | 15,886 | 11,527 | $21,171 39 | $19,924 53 | $7,283 74 | $48,379 66 |
| Brazil Block No. 8 | 29,260 | 5,850 | ..... | 35,110 | 9,203 | 1,850 | ..... | 11,053 | 4,377 | 41,786 | 31,891 60 | 29,603 81 | 9,731 96 | 71,227 37 |
| Brazil Block No. 10 | 22,872 | 4,575 | ..... | 27,447 | 11,794 | 2,370 | ..... | 14,164 | 4,902 | 36,709 | 31,510 27 | 16,954 78 | 6,999 04 | 55,464 09 |
| Brazil Block No. 11 | 1,393 | 280 | ..... | 1,673 | 12,580 | 2,505 | ..... | 15,085 | 1,801 | 14,957 | 14,546 73 | 6,881 84 | 3,607 05 | 25,035 62 |
| Diamond No. 5..... | 36,601 | 7,405 | ..... | 44,009 | 9,068 | 1,865 | ..... | 10,933 | 11,346 | 43,596 | 41,459 74 | 23,313 57 | 8,812 27 | 73,585 58 |
| Rob Roy ..... | Not reported. | | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Total..... | 100,208 | 20,125 | ..... | 120,333 | 55,409 | 11,145 | ..... | 66,554 | 38,312 | 148,575 | $140,579 73 | $96,678 53 | $36,434 06 | $273,692 32 |

### PARKE COUNTY.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Brazil Block No. 12 | 46,115 | 9,760 | ..... | 55,875 | 9,965 | 2,274 | ..... | 12,239 | 9,179 | 58,935 | $46,279 21 | $40,430 62 | $11,308 99 | $98,018 82 |
| Mary..... | 10,082 | 1,140 | ..... | 11,222 | 26,062 | 5,405 | ..... | 31,467 | 2,944 | 39,745 | 39,589 80 | 14,941 82 | 8,062 21 | 62,593 83 |
| Total..... | 56,197 | 10,900 | ..... | 67,097 | 36,027 | 7,679 | ..... | 43,706 | 12,123 | 98,680 | $85,869 01 | $55,372 44 | $19,371 20 | $160,612 65 |
| Total Machine Block ..... | 156,405 | 31,025 | ..... | 187,430 | 91,436 | 18,824 | ..... | 110,260 | 50,435 | 247,255 | $226,448 74 | $152,050 97 | $55,805 26 | $434,304 97 |

## BITUMINOUS MACHINE MINES.

### CLAY COUNTY.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gifford No. 1 | 18,483 | 9,475 | ..... | 27,958 | 17,682 | 3,450 | ..... | 21,132 | 14,884 | 34,206 | $29,471 56 | $17,347 10 | $6,788 33 | $53,606 99 |
| Gifford No. 2 | 32,157 | 2,915 | ..... | 35,072 | 61,528 | 28,268 | ..... | 89,796 | 35,072 | 89,796 | 82,115 27 | 42,607 14 | 10,126 32 | 134,848 73 |
| Total | 50,640 | 12,390 | ..... | 63,030 | 79,210 | 31,718 | ..... | 110,928 | 49,956 | 124,002 | $111,586 83 | $59,954 24 | $16,914 65 | $188,455 72 |

### GREENE COUNTY.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Black Creek | 32,855 | 18,226 | 29,030 | 80,111 | 29,478 | 16,036 | 26,496 | 72,010 | 75,116 | 76,905 | $80,168 03 | $30,372 10 | $9,113 00 | $119,653 13 |
| Island City No. 1 | ..... | ..... | 67,149 | 67,149 | ..... | ..... | 48,228 | 48,228 | 48,228 | 67,149 | 58,850 96 | 28,392 31 | 10,495 13 | 97,738 40 |
| Island City No. 2 | 35,375 | 12,602 | 62,797 | 110,774 | 17,414 | 6,027 | 32,142 | 55,583 | 55,583 | 110,774 | 91,062 50 | 30,499 74 | 18,288 36 | 139,850 60 |
| Gilmour | ..... | ..... | 136,024 | 136,024 | ..... | ..... | ..... | ..... | 85,403 | 50,181 | 72,995 22 | 23,953 00 | 8,694 28 | 105,642 50 |
| Hoosier No. 1 | 4,487 | 2,283 | 14,155 | 20,925 | ..... | ..... | ..... | ..... | 19,402 | 1,523 | 7,254 56 | 9,445 47 | 2,922 71 | 19,622 74 |
| Midland | 58,246 | 21,518 | 20,421 | 100,185 | 2,640 | 837 | 2,065 | 5,542 | 73,613 | 32,114 | 42,205 81 | 12,954 39 | 19,307 61 | 81,467 81 |
| Summit No. 2 | 37,402 | 9,769 | 100,460 | 147,631 | ..... | ..... | ..... | ..... | 71,118 | 76,513 | 65,355 61 | 27,949 77 | 16,754 63 | 110,060 01 |
| Glenburn | 26,816 | 13,873 | 58,526 | 99,215 | 11,151 | 6,249 | 17,165 | 34,565 | 107,263 | 26,517 | 77,681 73 | 25,994 07 | 8,712 04 | 112,387 84 |
| Antioch | 4,020 | 2,068 | 25,644 | 31,732 | 13,913 | 6,636 | 5,284 | 25,833 | 41,533 | 16,032 | 35,653 77 | 16,745 25 | 8,339 99 | 60,739 01 |
| Tower Hill | 31,962 | 12,913 | 1,503 | 46,378 | 10,108 | 4,019 | 704 | 14,831 | 37,891 | 23 318 | 30,127 95 | 15,451 81 | 7.542 73 | 53,122 49 |
| Green Valley | 26,881 | 24,343 | 35,162 | 86,386 | ..... | ..... | ..... | ..... | 39,071 | 47,315 | 45,154 35 | 19,877 70 | 10,205 20 | 75,237 25 |
| Lattis Creek No. 1 | 44,609 | 27,719 | 36,633 | 108,961 | 44 | ..... | 13 | 57 | 62,323 | 46,695 | 60,289 94 | 28,547 39 | 16,354 70 | 105,192 03 |
| Atlas No. 1 | 8,337 | 12,815 | 54,326 | 75,478 | 3,873 | ..... | 14,214 | 18,087 | 76,417 | 17,148 | 54,879 32 | 15,664 50 | 14.535 33 | 85,079 15 |
| Letsinger | 10,369 | 4,592 | 3,364 | 18,325 | ..... | ..... | 1,646 | 1,646 | 12,038 | 7,933 | 15,020 72 | 9,523 17 | 14,144 40 | 38,688 29 |
| North Western | 3,206 | 5,173 | 17,798 | 26,177 | 238 | 741 | 5,429 | 6,408 | 21,694 | 10,891 | 14,968 13 | 11,654 99 | 7,799 80 | 34,422 92 |
| Twin | 1,253 | 834 | 528 | 2,615 | 3,092 | 1,236 | 402 | 4,730 | 4,730 | 2,615 | 3,452 65 | 2,989 50 | 1,690 65 | 8,132 80 |
| Atlas No. 2 | ..... | ..... | 4,892 | 4,892 | ..... | ..... | 115 | 115 | 5,007 | ..... | 4,057 69 | 2,572 67 | 3,809 68 | 10,440 04 |
| Total | 325,818 | 168,728 | 668,412 | 1,162,958 | 91,951 | 41,781 | 153,903 | 287,635 | 836,870 | 613,723 | $766,178 94 | $312,587 83 | $178,710 24 | $1,257,477 01 |

### PARKE COUNTY.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lyford No. 1 | 7,560 | 3,138 | 11,382 | 22,080 | ..... | ..... | 16,974 | 16,974 | 6,492 | 32,562 | $16,355 88 | $14,017 64 | 5,336 76 | 35,710 28 |
| Parke No. 11 | ..... | ..... | 25,749 | 25,749 | ..... | ..... | 24,864 | 24,864 | 46,399 | 4,214 | 27,852 12 | 7 969 02 | 4,587 06 | 40,408 20 |
| Total | 7,560 | 3,138 | 37,131 | 47,829 | ..... | ..... | 41,838 | 41,838 | 52,891 | 36,776 | $44,208 00 | $21,986 66 | $9,923 82 | $76,118 48 |

## BITUMINOUS MACHINE MINES—Continued.

### SULLIVAN COUNTY.

| NAME OF MINE. | Machine Mined. | | | | Pick Mined. | | | | Distribution. | | Wages Paid. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons of Screened Coal. | Tons of Slack and Nut. | Tons of Mine-Run. | Total Tons of all Kinds of Coal Produced. | Tons of Screened Coal. | Tons of Slack and Nut. | Tons of Mine-Run. | Total Tons of all Kinds of Coal Produced. | Indiana. | Other States. | To Miners. | To Inside Day Men. | To Outside Day Men. | Total Wages. |
| Bunker Hill | 17,884 | 5,960 | 5,019 | 28,863 | 16,912 | 7,745 | 1,183 | 25,840 | ..... | 54,703 | $34,702 86 | $18,918 00 | $7,993 68 | $61,614 54 |
| Caledonia | 21,846 | 10,768 | 4,342 | 36,956 | 15,691 | 5,282 | 7,104 | 28,077 | 8,710 | 56,323 | 35,502 95 | 18,434 61 | 9,867 56 | 63,805 12 |
| Dugger | 27,281 | 9,429 | 31,700 | 68,410 | 2,336 | 778 | 2,575 | 5,689 | 19,524 | 54,575 | 36,879 80 | 27,756 73 | 9,366 32 | 74,002 85 |
| Green Hill | 25,386 | 11,826 | 3,034 | 40,246 | 1,584 | 646 | ..... | 2,230 | 520 | 41,956 | 20,399 81 | 17,576 83 | 6,509 79 | 44,486 43 |
| Hymera No. 1 | 60,719 | 45,082 | 50,591 | 156,392 | ..... | ..... | ..... | ..... | 41,402 | 114,990 | 71,948 53 | 28,578 04 | 14.734 34 | 115,260 91 |
| Jackson Hill No. 2 | 89,071 | 64,659 | 42,685 | 196,415 | ..... | ..... | ..... | ..... | 80,401 | 116,014 | 81,851 79 | 35,046 12 | 10,932 08 | 127,829 99 |
| Phoenix No. 3 | ..... | ..... | 128,036 | 128,036 | ..... | ..... | ..... | ..... | 67,470 | 60,566 | 65,321 65 | 24,486 53 | 12,303 19 | 102,111 37 |
| Phoenix No. 5 | ..... | ..... | 17,416 | 17,416 | ..... | ..... | ..... | ..... | 9,000 | 8,416 | 10,093 00 | 3,839 00 | 1,143 00 | 15,075 00 |
| Shelburn | 10,288 | 5,351 | 195 | 15,834 | 2.054 | 1,253 | 27 | 3,334 | 9,955 | 9,213 | 10,707 82 | 8,136 30 | 5,997 35 | 28,841 47 |
| Star City | 62,606 | 35,167 | 7,966 | 105,739 | 21,877 | 11,079 | 2,543 | 35,499 | 30,986 | 110,252 | 67,618 42 | 32,231 43 | 16,391 48 | 116,241 33 |
| Sun Flower | 103,717 | 34,852 | 1,763 | 139,832 | ..... | ..... | 15 | 15 | 32,815 | 107,032 | 71,233 61 | 7,143 90 | 13,518 90 | 91,896 41 |
| Glendora | 76,901 | 36,901 | 49,966 | 163,768 | ..... | ..... | ..... | ..... | 58,774 | 104,994 | 79,628 44 | 35,571 10 | 18,446 95 | 133,646 49 |
| Hymera No. 2 | 61,611 | 56,803 | 34,356 | 152,770 | ..... | ..... | ..... | ..... | 24,061 | 128,709 | 69,301 10 | 21,928 55 | 12,470 77 | 103,700 42 |
| Wilfred No. 1 | 79,894 | 34,873 | 16,079 | 130,846 | ..... | ..... | ..... | ..... | 44,020 | 86,826 | 64,755 76 | 27,576 38 | 23,329 61 | 115,661 75 |
| Little Giant | Tonnage not reported. | | | | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Cummins | ..... | ..... | 2,000 | 2,000 | ..... | ..... | 1,300 | 1,300 | 2,000 | 1,300 | 2,500 00 | 1,500 00 | 1,045 00 | 5,045 00 |
| Mildred | ..... | ..... | 1,745 | 1,745 | ..... | ..... | ..... | ..... | 1,745 | ..... | 851 35 | 1,052 90 | 1,047 50 | 2,951 75 |
| West Linton | ..... | ..... | 280 | 280 | ..... | ..... | 546 | 546 | 826 | ..... | 530 51 | 370 00 | 986 01 | 1,886 52 |
| Total | 637,204 | 351,171 | 397,173 | 1,385,548 | 60,454 | 26,783 | 15,293 | 102,530 | 432,209 | 1,055,869 | $723,827 40 | $310,146 42 | $166,083 53 | $1,200,057 35 |

## VIGO COUNTY.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atherton | 25,776 | 13,536 | 401 | 39,713 | 12,155 | 9,217 | 166 | 21,538 | 573 | 60,678 | $30,773 76 | $7,115 59 | $6,291 57 | $44,180 92 |
| Lawton | 2,353 | 1,567 | ..... | 3,920 | 50,925 | 25,278 | 21,156 | 97,359 | 97,359 | 3,920 | 65,561 70 | 17,471 80 | 7,588 20 | 90,621 70 |
| Glen Oak | ..... | ..... | 165,115 | 165,115 | ..... | ..... | 4,938 | 4,938 | ..... | 170,053 | 83,897 72 | 45,967 59 | 15,853 31 | 145,718 62 |
| Parke No. 10 | 26,308 | 19,969 | 100,711 | 146,988 | ..... | ..... | ..... | ..... | 120,865 | 26,123 | 70,062 10 | 25,861 07 | 12,447 12 | 108,370 29 |
| Nickel Plate | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Total | 54,437 | 35,072 | 266,227 | 355,736 | 63,080 | 34,495 | 26,260 | 123,835 | 218,797 | 260,774 | $250,295 28 | $96,416 05 | $42,180 20 | $388,891 53 |

## WARRICK COUNTY.

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Big Four | ..... | ..... | 96,231 | 96,231 | ..... | ..... | ..... | ..... | 50,309 | 45,922 | $42,117 47 | $8,256 84 | $5,770 27 | $56,144 58 |
| Big Vein No. 3 | ..... | ..... | 74,003 | 74,003 | ..... | ..... | ..... | ..... | 74,003 | ..... | 36,615 55 | 6,049 90 | 5,180 75 | 47,846 20 |
| Electric | 8,005 | 3,686 | 19,622 | 31,313 | ..... | ..... | ..... | ..... | 10,160 | 21,153 | 13,931 39 | 4,186 22 | 2,774 54 | 20,892 15 |
| Total | 8,005 | 3,686 | 189,856 | 201,547 | ..... | ..... | ..... | ..... | 134,472 | 67,075 | $92,664 41 | $18,492 96 | $13,725 56 | $124,882 93 |
| Total Bituminous Machine Mined Coal | 1,083,664 | 574,185 | 1,558,799 | 3,216,648 | 294,695 | 134,777 | 237,294 | 666,766 | 1,725,195 | 2,158,219 | $1,988,760 86 | $819,584 16 | $427,538 00 | $3,235,883 02 |
| Total Machine Mined Block Coal | 156,405 | 31,025 | ..... | 187,430 | 91,436 | 18,824 | ..... | 110,260 | 50,435 | 247,255 | 226,448 74 | 152,050 97 | 55,805 26 | 434,304 97 |
| Total Machine Mined | 1,240,069 | 605,210 | 1,558,799 | 3,404,078 | 386,131 | 153,601 | 237,294 | 777,026 | 1,775,630 | 2,405,474 | $2,215,209 60 | $971,635 13 | $483,343 26 | $3,670,187 99 |

## BLOCK COAL—HAND OR PICK MINES.

### CLAY COUNTY.

| NAME OF MINE. | Production. | | | | Distribution. | | Wages. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons of Screened Coal. | Tons of Slack and Nut Coal. | Tons of Mine-Run Coal. | Total Tons of all Kinds of Coal Produced. | Indiana. | Other States. | To Miners. | To Inside Day Men. | To Outside Day Men. | Total Wages Paid. |
| Continental No. 1 | 6 957 | 1,685 | ..... | 8,642 | ..... | 8,642 | $9,402 57 | $3,609 03 | $2,018 99 | $15,030 59 |
| Gart No. 5 | 3,754 | 745 | ..... | 4,499 | 2,794 | 1,705 | 3,915 25 | 887 67 | 909 76 | 5,712 68 |
| Gart No. 7 | 28,075 | 5,630 | ..... | 33,705 | 19,581 | 14,124 | 38,425 40 | 13,019 03 | 6,916 68 | 58,361 11 |
| Rebstock | 2,065 | 500 | ..... | 2,565 | 740 | 1,825 | 3,006 64 | 1,016 99 | 1,204 52 | 5,228 15 |
| Lawrence No. 6 | 45,563 | 10,700 | ..... | 56,263 | 32,222 | 24,041 | 46,835 91 | 9,422 13 | 5,894 36 | 62,152 40 |
| Lawrence No. 7 | 46,759 | 11,768 | 1,421 | 59,948 | 34,130 | 25,818 | 58,431 66 | 18,986 08 | 10,511 53 | 87,929 27 |
| Cornwell | 31,614 | 6,136 | ..... | 37,750 | 37,750 | ..... | 33,219 43 | 10,549 91 | 4,442 27 | 48,211 61 |
| Crawford No. 2 | 29,491 | 8,095 | 765 | 38,351 | 18,645 | 19,706 | 30,674 59 | 7,008 83 | 4,732 97 | 42,416 39 |
| Crawford No. 3 | 13,478 | 2,430 | ..... | 15,908 | 6,240 | 9,668 | 13,122 18 | 2,752 05 | 1,895 84 | 17,770 07 |
| Crawford No. 6 | 20,571 | 6,445 | 263 | 27,279 | 13,453 | 13,826 | 25,148 99 | 5,896 25 | 3,688 81 | 34,734 05 |
| Crawford No. 7 | 33,389 | 7,919 | ..... | 41,308 | 22,171 | 19,137 | 35,388 02 | 10,623 59 | 5,912 39 | 51,924 00 |
| Eureka No. 2 | 857 | 100 | ..... | 957 | 275 | 682 | 887 05 | 609 55 | 525 25 | 2,021 85 |
| Eureka No. 3 | 13,475 | 1,477 | 601 | 15,553 | 4,752 | 10,801 | 12,715 90 | 6,414 15 | 5,309 25 | 24,439 30 |
| Pratt | 6,991 | 1,515 | 672 | 9,178 | 9,107 | 71 | 7,084 30 | 3,065 45 | 1,532 60 | 11,682 35 |
| Monarch | ..... | ..... | 9,244 | 9,244 | 9,244 | ..... | See note | 13,262 29 | 2,168 35 | 15,430 64 |
| Rob Roy | Not reported | | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Crawford No. 5 | 22,648 | 6,384 | 9,312 | 38,344 | 20,210 | 18,134 | 34,524 37 | 9,071 98 | 5,086 38 | 48,682 73 |
| Total | 305,687 | 71,529 | 22,278 | 399,494 | 231,314 | 168,180 | $352,782 26 | $116,194 98 | $62,749 95 | $531,727 19 |

## PARKE COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Crawford No. 10 | 13,368 | 1,985 | ..... | 15,353 | 994 | 14,359 | $13,055 52 | $4,138 91 | $2,235 23 | $19,429 66 |
| Superior No. 1 | 69,295 | 16,930 | 160 | 86,385 | 21,330 | 65,055 | 74,317 47 | 18,214 79 | 10,396 46 | 102,928 72 |
| Superior No. 2 | 48,917 | 11,980 | 773 | 61,670 | 25,130 | 36,540 | 52,403 98 | 21,063 31 | 11,596 45 | 85,063 74 |
| Superior No. 3 | 35,158 | 8,605 | ..... | 43,763 | 12,178 | 31,585 | 43,922 53 | 10,281 84 | 5,757 91 | 59,962 28 |
| Pan American | 68,807 | 10,545 | 933 | 75,285 | 24,850 | 50,435 | 73,506 30 | 21,936 20 | 7,614 20 | 103,056 70 |
| Brasil Block No. 9 | 38,580 | 7,720 | ..... | 46,300 | 5,267 | 41,033 | 44,243 04 | 15,512 39 | 6,707 30 | 66,462 73 |
| Total | 269,125 | 57,765 | 1,866 | 328,756 | 89,749 | 239,007 | $301,448 84 | $91,147 44 | $44,307 55 | $436,903 83 |
| Total Pick Mined | 574,812 | 129,294 | 24,144 | 728,250 | 321,063 | 407,187 | $654,231 10 | $207,342 42 | $107,057 50 | $968,631 02 |

## BITUMINOUS PICK MINES.

### CLAY COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cloverland No 1 | 91,546 | 33,015 | 33,480 | 158,041 | 85,613 | 72,428 | $104,755 58 | $26,313 30 | $13,334 88 | $144,403 76 |
| Fair View | 1,626 | 1,549 | ..... | 3,175 | 1,707 | 1,468 | 2,223 16 | 1,033 65 | 1,062 45 | 4,319 26 |
| Fortner | 15,652 | 6,725 | 5,762 | 28,139 | 21,253 | 6,886 | 18,583 46 | 4,224 10 | 1,961 57 | 24,769 13 |
| Klondyke | 40,221 | 19,852 | 18,069 | 78,142 | 72,968 | 5,174 | 45,660 45 | 12,317 97 | 5,790 58 | 63,769 00 |
| Glen | 46,183 | 12,805 | ..... | 58,988 | 21,050 | 37,938 | 47,381 75 | 9,355 35 | 4,600 50 | 61,337 60 |
| Pearl | 58,471 | 36,269 | 2,122 | 96,862 | 57.832 | 39,030 | 56,745 24 | 13,796 20 | 6,251 55 | 76,792 99 |
| Silverwood | 16,149 | 9,910 | ..... | 26,059 | 14,499 | 11,560 | 16,645 60 | 6,362 70 | 4,125 70 | 27,134 00 |
| Cloverland No 2 | 7,743 | 2,540 | ..... | 10,283 | 1,700 | 8,583 | 11,659 00 | 2,754 58 | 1,216 71 | 15,630 29 |
| Lewis | ..... | ..... | 2,446 | 2,446 | 312 | 2,134 | 1,100 00 | 921 19 | 1,455 61 | 3,476 80 |
| Total | 277,591 | 122,665 | 61,879 | 462,135 | 276,934 | 185,201 | $304,754 24 | $77,079 04 | $39,799 55 | $421,632 83 |

### DAVIESS COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cabel No. 4 | 2,892 | 1,205 | ..... | 4,097 | 4,097 | ..... | $2,978 77 | $854 10 | $916 75 | $4,749 62 |
| Cabel No. 9 | 7,147 | 3,754 | 18,523 | 29,424 | 22,277 | 7,147 | 16,918 80 | 8,554 40 | 3,909 95 | 29,383 15 |
| Montgomery Nos. 2 and 3 | 93,008 | 13,319 | 9,942 | 116,269 | 75,996 | 40,273 | 83,383 20 | 25,268 00 | 11,986 64 | 120,637 84 |
| Mutual | 12,985 | 1,750 | 12,137 | 26,872 | 14,850 | 12,022 | 19,776 90 | 5,000 50 | 3,055 00 | 27,832 40 |
| Union | ..... | ..... | 8,494 | 8,494 | 8,494 | ..... | 5,319 18 | 1,590 04 | 787 53 | 7,696 75 |
| Mandabach | 175 | 119 | 3,250 | 3,535 | 3,535 | ..... | 1,636 20 | 212 34 | 185 20 | 2,033 74 |
| Wheatland | 187 | 150 | 2,131 | 2,468 | 2,363 | 105 | 1,400 00 | 1,023 75 | 684 87 | 3,108 62 |
| Total | 116,394 | 20,288 | 54,477 | 1911 59 | 131,612 | 59,547 | $131,413 05 | $42,503 13 | $21,525 94 | $195,442 12 |

## BITIUMINOUS PICK MINES—Continued.

### FOUNTAIN COUNTY.

| NAME OF MINE. | Production. | | | | Distribution. | | Wages. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons of Screened Coal. | Tons of Slack and Nut Coal. | Tons of Mine-Run Coal. | Total Tons of all Kinds of Coal Produced. | Indiana. | Other States. | To Miners. | To Inside Day Men. | To Outside Day Men. | Total Wages Paid. |
| Diamond | 349 | 90 | 208 | 647 | 622 | 25 | $367 33 | $285 47 | $156 10 | $808 90 |
| Rush | 4,070 | 1,460 | 9,933 | 15,463 | 15,463 | ..... | 8,661 00 | 1,461 00 | 1,294 00 | 11,416 00 |
| Silverwood | 245 | 90 | 176 | 510 | 450 | 60 | ..... ..... | 784 90 | 326 39 | 1,111 29 |
| Total | 4,664 | 1,640 | 10,316 | 16,620 | 16,535 | 85 | $9,028 33 | $2,531 37 | $1,776 49 | $13,336 19 |

### GIBSON COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Oswald | 13,005 | 13,261 | 20,434 | 46,700 | 40,866 | 5,834 | $24,854 19 | $15,609 54 | $10,769 33 | $51,233 06 |
| Total | 13,005 | 13,261 | 20,434 | 46,700 | 40,866 | 5,834 | $24,854 19 | $15,609 54 | $10,769 33 | $51,233 06 |

### GREENE COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Island No. 3 | ..... | ..... | 92,574 | 92,574 | 7,574 | 85,000 | $54,252 86 | $18,100 55 | $8,432 24 | $80,785 65 |
| Island Valley No. 3 | 42,528 | 21,754 | 63,306 | 127,588 | 81,873 | 45,715 | 74,244 34 | 19,845 46 | 8,100 13 | 102,189 93 |
| Island Valley No. 2 | 21,634 | 14,264 | ..... | 35,898 | 21,686 | 14,212 | 19,600 80 | 8,910 92 | 4,850 59 | 33,362 31 |
| South Linton | 33,505 | 18,556 | 102,712 | 154,773 | 93,763 | 61,010 | 93,616 87 | 23,512 01 | 7,786 47 | 124,915 35 |
| Vulcan | 2,756 | 1,116 | 4,280 | 8,152 | 201 | 7,951 | 5,009 33 | 1,033 50 | 1,511 57 | 7,554 40 |
| Templeton | 9,933 | 4,410 | 99,897 | 114,240 | 114,240 | ..... | 65,984 80 | 17,100 55 | 8,256 05 | 91,341 40 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Victoria | 27,810 | 25,422 | 169,838 | 223,070 | 210,616 | 12,454 | 132,104 88 | 19,921 67 | 10,564 60 | 162,591 15 |
| Fry | ..... | ..... | 14,464 | 14,464 | 14,464 | ..... | 12,785 82 | 4,540 53 | 2,033 35 | 19,359 70 |
| Island No. 5 | ..... | ..... | 5,439 | 5,439 | 5,439 | ..... | 4,741 10 | 2,213 45 | 1,513 94 | 8,468 49 |
| Total | 138,166 | 85,522 | 552,510 | 776,198 | 549,856 | 226,342 | $462,340 80 | $115,178 64 | $53,048 94 | $630,568 38 |

## KNOX COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bicknell | 20,222 | 17,421 | 20,838 | 58,481 | 57,706 | 775 | $29,846 92 | $8,530 96 | $6,009 66 | $44,387 54 |
| Edwardsport | 22 | 75 | 6,707 | 6,804 | 6,804 | ..... | 4,256 94 | 1,171 95 | 797 65 | 6,226 54 |
| Knox | 16,637 | 13,435 | 20,827 | 50,899 | 42,590 | 8,309 | 25,447 49 | 12,352 05 | 5,381 85 | 43,181 39 |
| Lynn | ..... | ..... | 12,486 | 12,486 | 11,467 | 1,019 | 7,825 60 | 1,556 47 | 1,570 93 | 10,953 00 |
| Prospect Hill | 3,694 | 2,581 | 3,004 | 9,279 | 9,279 | ..... | 11,419 97 | 4,506 99 | 1,916 18 | 17,843 14 |
| Enterprise | No report | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Total | 40,575 | 33,512 | 63,862 | 137,949 | 127,846 | 10,103 | $78,796 92 | $28,118 42 | $15,676 27 | $122,591 61 |

## PARKE COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| C. B. Harrison | 395 | 130 | 3,971 | 4,496 | 4,496 | ..... | $2,323 30 | $719 50 | $412 00 | 3,454 80 |
| W. P. Harrison | ..... | ..... | 10,990 | 10,990 | 10,990 | ..... | 6,011 50 | 2,536 40 | 1,240 00 | 9,787 90 |
| Cox No. 3 | ..... | ..... | 97,459 | 97,459 | 82,769 | 14,690 | 58,106 05 | 27,905 35 | 10,268 23 | 96,279 63 |
| Lucia | 18,412 | 7,681 | 31,050 | 57,143 | 37,106 | 20,037 | 35,442 72 | 13,218 73 | 7,873 39 | 56,529 84 |
| Mecca No. 1 | 21,882 | 11,411 | 2,350 | 35,643 | 8,154 | 27,489 | 22,700 20 | 11,473 69 | 6,073 86 | 40,247 75 |
| New Century | 18,768 | 9,990 | 7,885 | 36,643 | 11,995 | 24,648 | 23,053 41 | 8,429 62 | 4,740 37 | 36,223 40 |
| Minshal No. 1 | 90,298 | 18,056 | 19,930 | 128,284 | 128,284 | ..... | 102,016 28 | 28,212 82 | 11,330 18 | 141,559 28 |
| Briar Hill | ..... | ..... | 22,162 | 22,162 | 22,162 | ..... | 18,194 04 | 7,002 48 | 3,716 41 | 28,912 93 |
| Minshal No. 2 | 656 | 189 | 103 | 948 | 143 | 805 | 528 42 | 874 18 | 471 17 | 1,873 77 |
| Total | 150,411 | 47,457 | 195,900 | 393,768 | 306,099 | 87,669 | $268,375 92 | $100,367 77 | $46,125 61 | $414,869 30 |

## PERRY COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Troy | ..... | ..... | 10,630 | 10,630 | 10,630 | ..... | $7,139 99 | $1,914 69 | $1,632 92 | $10,587 60 |
| Cannelton | 273 | 84 | 133 | 490 | 490 | ..... | 272 75 | 155 00 | 100 00 | 527 75 |
| Total | 273 | 84 | 10,763 | 11,120 | 11,120 | ..... | $7,412 74 | $2,069 69 | $1,632 92 | $11,115 35 |

## BITUMINOUS PICK MINES—Continued.

### PIKE COUNTY.

| NAME OF MINE. | Production. | | | | Distribution. | | Wages. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons of Screened Coal. | Tons of Slack and Nut Coal. | Tons of Mine-Run Coal. | Total Tons of all Kinds of Coal Produced. | Indiana. | Other States. | To Miners. | To Inside Day Men. | To Outside Day Men. | Total Wages Paid. |
| Massey | 4,179 | 2,910 | 10,590 | 17,679 | 16,501 | 1,178 | $13,667 03 | $4,506 04 | $2,590 49 | $20,765 56 |
| Aberdeen | 2,984 | 2,450 | 14,756 | 20,190 | 5,853 | 14,337 | 11,719 07 | 4,138 41 | 2,575 81 | 18,433 29 |
| Ayrshire No. 3 | 26,158 | 16,407 | 10,609 | 53,174 | 35,518 | 17,656 | 27,254 36 | 14,079 17 | 7,186 80 | 49,120 33 |
| Ayrshire No. 4 | 31,241 | 11,873 | 47,260 | 90,374 | 53,428 | 36,946 | 55,362 34 | 15,243 60 | 7,641 25 | 78,747 19 |
| Ayrshire No. 5 | 179 | 192 | 5,050 | 5,421 | 4,176 | 1,245 | 2,848 23 | 1,053 22 | 790 82 | 4,692 27 |
| Ayrshire No. 6 | No report. | | | | | | | | | |
| Blackburn | 629 | 791 | 31,248 | 32,668 | 30,382 | 2,286 | 18,816 04 | 7,078 81 | 3,768 75 | 29,163 60 |
| Hartwell | 3,117 | 1,911 | 45,479 | 50,507 | 42,025 | 8,482 | 33,016 31 | 12,414 63 | 8,035 44 | 53,466 38 |
| Little's | 33,252 | 45,472 | 22,335 | 101,059 | 81,936 | 19,123 | 58,344 09 | 17,294 22 | 6,782 80 | 82,421 11 |
| Rogers | | | 2,670 | 2,670 | 2,670 | | 1,575 65 | 636 03 | 158 36 | 2,170 04 |
| Petersburg | | | 36,150 | 36,150 | 33,486 | 2,664 | 22,754 69 | 7,176 90 | 3,235 75 | 33,167 34 |
| Carbon | 2,114 | 1,833 | 8,274 | 12,221 | 7,917 | 4,304 | 7,542 54 | 4,035 43 | 1,939 68 | 13,517 65 |
| Winslow | 23,353 | 16,743 | 23,019 | 62,115 | 62,115 | | 38,724 96 | 18,048 21 | 7,473 86 | 64,247 03 |
| Total | 126,206 | 100,582 | 257,440 | 484,228 | 376,007 | 109,221 | $292,045 31 | $105,706 67 | $52,180 01 | $449,931 99 |

### SULLIVAN COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| White Ash | 3,640 | 41,232 | 46,477 | 30,987 | 15,490 | $28,411 83 | $8,756 49 | $4,874 97 | $42,043 29 |
| Freeman | 6,342 | 1,955 | 13,937 | 4,390 | 9,547 | 10,799 49 | 2,805 65 | 2,996 72 | 16,601 86 |
| Island No. 4 | Not rep | | | | | | | | |
| Lablanze | | 2,259 | 2,259 | 2,259 | | 400 00 | 205 00 | 1,336 00 | 1,941 00 |
| Citizens | 470 | 350 | 1,270 | 1,270 | | 1,054 44 | 243 20 | 247 70 | 1,545 34 |
| Brailettes No. 6 | | 1,317 | 1,317 | | 1,317 | 2,248 15 | | | 2,248 15 |
| Total | 12,452 | 47,113 | 65,260 | 38,906 | 26,454 | $42,913 91 | $12,010 34 | $9,455 39 | $64,379 64 |

## VANDERBURGH COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Diamond | 13,872 | 8,908 | 10,066 | 32,846 | 31,435 | 1,411 | $20,740 27 | $4,556 34 | $3,800 53 | $29,097 14 |
| First Avenue | 3,236 | 2,487 | 1,944 | 7,667 | 6,989 | 678 | 5,390 25 | 1,380 25 | 1,255 90 | 8,026 40 |
| Ingleside | Not reported | | | | | | | | | |
| Sunny Side | 9,006 | 16,823 | 27,828 | 53,657 | 27,076 | 26,581 | 29,335 06 | 15,279 49 | 7,085 09 | 51,699 64 |
| Union | 10,409 | 5,216 | 10,409 | 26,034 | 26,034 | | 20,226 60 | 4,454 55 | 3,510 40 | 28,191 55 |
| Unity | 21,451 | 1,000 | 61,993 | 84,444 | 84,444 | | 58,500 10 | 9,865 05 | 7,355 90 | 75,721 05 |
| Total | 57,974 | 34,434 | 112,240 | 204,648 | 175,978 | 28,670 | $134,192 28 | $35,535 68 | $23,007 82 | $192,735 78 |

## VERMILLION COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Bruilettes No. 3 | 5,524 | 10,003 | 96,076 | 111,603 | 16,238 | 95,365 | $58,952 80 | $15,086 25 | $10,070 85 | $84,109 90 |
| Bruilettes No. 4 | 502 | 308 | 11,848 | 12,658 | 3,178 | 9,480 | 6,207 35 | 1,989 55 | 685 30 | 8,882 20 |
| Bruilettes No. 5 | 52,455 | 30,323 | 86,712 | 169,490 | 25,593 | 143,897 | 99,973 92 | 21,306 15 | 8,738 20 | 130,016 27 |
| Buckeye | 17,302 | 9,572 | 16,698 | 43,572 | | 43,572 | 25,311 16 | 10,021 37 | 6,639 50 | 41,972 03 |
| Eureka | | | 10,007 | 10,007 | 10,007 | | 7,200 74 | 3,489 66 | 1,854 39 | 12,544 79 |
| Crown Hill No. 1 | 65,956 | 32,087 | 59,454 | 157,497 | 12,498 | 145,000 | 89,346 11 | 17,182 00 | 6,188 00 | 112,716 11 |
| Crown Hill No. 2 | | | 5,425 | 5,425 | 1,515 | 3,910 | 2,200 00 | 2,925 33 | 1,308 87 | 6,434 20 |
| Oak Hill | 36,143 | 21,060 | 80,364 | 137,557 | | 137,557 | 79,739 82 | 22,839 97 | 11,380 60 | 113,960 39 |
| Prince | | | 174,862 | 174,862 | 1,354 | 173,508 | 97,677 10 | 27,778 08 | 9,625 88 | 135,081 06 |
| Willow Grove | 18,319 | 6,725 | 81,673 | 106,717 | 4,492 | 102,225 | 65,161 29 | 10,049 19 | 8,695 53 | 83,906 01 |
| Rhoades | 334 | 160 | 12,283 | 12,777 | 12,283 | 494 | 7,058 78 | 7,403 66 | 4,362 37 | 18,824 81 |
| Total | 196,535 | 110,228 | 635,402 | 942,165 | 87,157 | 855,008 | $538,829 07 | $140,071 21 | $69,547 49 | $748,447 77 |

## VIGO COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Brick Works | | | 6,470 | 6,470 | 6,470 | | $4,071 67 | $1,776 79 | $726 92 | $6,575 38 |
| Chicago No. 6 | 24,435 | 9,762 | 197 | 34,394 | 5,566 | 28,828 | 25,528 98 | 8,123 52 | 3,561 92 | 37,214 42 |
| Diamond | 54,373 | 26,080 | 16,177 | 96,630 | 96,630 | | 63,327 05 | 24,607 80 | 9,567 75 | 97,502 60 |
| Peerless | 35,177 | 18,965 | 6,010 | 60,152 | | 60,152 | 41,428 55 | 14,183 40 | 7,089 75 | 62,701 70 |
| Union | 30,935 | 8,345 | 41,545 | 80,825 | 80,825 | | 49,955 15 | 16,841 90 | 10,225 30 | 77,022 35 |
| Ehrlich | 14,524 | 9,236 | | 23,760 | 22,952 | 808 | 13,404 47 | 5,978 10 | 3,613 70 | 22,996 27 |
| Grant No. 2 | 25,680 | 29,185 | 48,578 | 103,443 | 16,901 | 86,542 | 63,496 28 | 19,899 55 | 10,366 84 | 93,762 67 |
| Hector | 28,251 | 20,154 | 17,409 | 65,814 | 57,672 | 8,142 | 39,632 83 | 14,142 58 | 7,637 34 | 61,412 75 |
| Klondyke | 29,166 | 23,530 | 42,744 | 95,440 | 6,482 | 88,958 | 47,543 15 | 15,964 05 | 6,140 10 | 69,647 30 |
| Miami No 1 | 114,706 | 31,360 | 3,494 | 149,560 | | 149,560 | 142,253 12 | 19,324 48 | 7,293 94 | 168,871 54 |
| Nickle Plate | 11,877 | 4,140 | 11,257 | 27,274 | | 27,274 | 15,374 82 | 5,600 78 | 2,560 79 | 23,536 39 |

## BITUMINOUS PICK MINES—Continued.

### VIGO COUNTY—Continued.

| NAME OF MINE. | Production. | | | | Distribution. | | Wages. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tons of Screened Coal. | Tons of Slack and Nut Coal. | Tons of Mine-Run Coal. | Total Tons of all Kinds of Coal Produced. | Indiana. | Other States. | To Miners. | To Inside Day Men. | To Outside Day Men. | Total Wages Paid. |
| Ray | 2,994 | 2,778 | 3,101 | 8,873 | 2,957 | 5,916 | $4,491 82 | $945 18 | $485 35 | $5,922 35 |
| Redbird | 12,455 | 12,420 | 25,028 | 49,903 | 49,903 | ..... | 23,243 98 | 4,957 32 | 2,950 16 | 31,151 46 |
| Rosebud No. 2 | 85,657 | 47,533 | 17,838 | 151,028 | 132,801 | 18,227 | 92,285 80 | 23,210 05 | 8,644 95 | 124,140 80 |
| Royal No. 1 | 15,279 | 8,462 | 80,501 | 104,242 | 101,445 | 2,797 | 62,614 37 | 14,442 38 | 4,890 15 | 81,946 90 |
| Larimer | ..... | ..... | 12,249 | 12,249 | 12,249 | ..... | 7,005 83 | 2,594 27 | 1,643 74 | 11,243 84 |
| Broadhurst | 8,062 | 8,081 | 58,659 | 74,802 | 45,872 | 28,930 | 32,675 63 | 6,009 01 | 4,253 43 | 42,938 07 |
| Miami No. 2 | 2,044 | 635 | 16,205 | 18,884 | ..... | 18,884 | 14,869 47 | 2,281 04 | 2,881 59 | 20,032 10 |
| Deep Vein | 10,353 | 7,298 | 10,067 | 27,718 | 25,460 | 2,258 | 16,502 34 | 5,053 79 | 2,743 87 | 24,300 00 |
| Greenfield No. 1 | 15,914 | 10,115 | 10,186 | 36,215 | 36,215 | ..... | 22,013 05 | 4,612 82 | 3,879 30 | 30,505 17 |
| Lost Creek | ..... | ..... | 8,496 | 8,496 | 1,290 | 7,206 | 5,291 15 | 2,093 21 | 1,734 59 | 9,118 95 |
| Sugar Creek No. 1 | 619 | 123 | 241 | 983 | 983 | ..... | 1,252 51 | 546 51 | 528 24 | 2,327 26 |
| Total | 522,501 | 278,202 | 436,452 | 1,237,155 | 702,673 | 534,482 | $788,262 02 | $213,188 53 | $103,419 72 | 1,104,870 27 |

### WARRICK COUNTY.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Air Line | 9,905 | 4,635 | 11,530 | 26,070 | 8,530 | 17,540 | $15,896 55 | $2,844 50 | $1,683 94 | $20,424 99 |
| Caledonia | ..... | ..... | 13,157 | 13,157 | 9,232 | 3,925 | 6,957 60 | 1,867 57 | 1,208 95 | 10,034 12 |
| Chandler | 7,650 | 3,810 | 17,315 | 28,775 | 7,045 | 21,730 | 16,368 25 | 5,255 45 | 1,836 45 | 23,460 15 |
| DeForrest | 5,220 | 3,056 | 4,540 | 12,815 | 12,815 | ..... | 7,118 35 | 1,200 21 | 791 06 | 8,109 62 |
| Star No. 1 | ..... | ..... | 33,277 | 33,277 | 33,277 | ..... | 18,020 97 | 5,000 97 | 3,548 00 | 26,569 94 |
| Total | 22,775 | 11,500 | 79,819 | 114,094 | 70,899 | 43,195 | $64,361 72 | $16,168 70 | $9,068 40 | $89,598 82 |
| Total Hand Bituminous | 1,679,522 | 865,070 | 2,538,607 | 5,083,199 | 2,912,388 | 2,170,811 | $3,147,580 50 | $906,138 73 | $457,033 88 | $4,510,753 11 |

# RECAPITULATION.

*Showing Total Production and Wages of Indiana Mines for 1903.*

| | Machine Mined. | | | | Pick Mined. | | | | Distribution. | | | Wages. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Screened. | Slack and Nut. | Mine-Run. | Total. | Screened. | Slack and Nut. | Mine-Run. | Total. | Indiana. | Other States. | Miners. | Inside Day and Monthly Men. | Outside Day and Monthly Men. | Total. |
| Total production block machine mines | 156,405 | 31,025 | ..... | 187,430 | 91,436 | 18,824 | ..... | 110,260 | 50,435 | 247,255 | $226,448 74 | $152,050 97 | $55,805 26 | $434,304 97 |
| Total production block pick mines | ..... | ..... | ..... | ..... | 574,812 | 129,294 | 24,144 | 728,250 | 321,063 | 407,187 | 654,231 10 | 207,342 42 | 107,057 50 | 968,631 02 |
| Total block... | 156,405 | 31,025 | ..... | 187,430 | 666,248 | 148,118 | 24,144 | 838,510 | 371,498 | 654,442 | $880,679 84 | $359,393 39 | $162,862 76 | $1,402,935 99 |
| Total bituminous machine mines. | 1,083,664 | 574,185 | 1,558,799 | 3,216,648 | 294,695 | 134,777 | 237,294 | 666,766 | 1,725,195 | 2,158,219 | $1,988,760 86 | $819,584 16 | $427,538 00 | $3,235,883 02 |
| Total bituminous pick mines | ..... | ..... | ..... | ..... | 1,679,522 | 865,070 | 2,538,607 | 5,083,199 | 2,912,388 | 2,170,811 | 3,147,580 50 | 906,138 73 | 457,033 88 | 4,510,753 11 |
| Total bituminous | 1,083,664 | 574,185 | 1,558,799 | 3,216,648 | 1,974,217 | 999,847 | 2,775,901 | 5,749,965 | 4,637,583 | 4,329,030 | $5,136,341 36 | $1,725,722 89 | $884,571 88 | $7,746,636 13 |
| Total machine mined | 1,240,069 | 605,210 | 1,558,799 | 3,404,078 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Total pick mined | 2,640,465 | 1,147,965 | 2,800.045 | 6,588,475 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Grand total... | 3,880,534 | 1,753,175 | 4,358,844 | 9,992,553 | ..... | ..... | ..... | ..... | ..... | ..... | $6,017,021 20 | $2,085,116 28 | $1,047,434 64 | $9,149,572 12 |

## TABLE,

*Showing by Counties the Number of Kegs of Powder Used at the Mines During the Year 1903, also Price Per Keg to Miners, and Tons of Coal Produced Per Keg.*

| COUNTY. | Tons. | Kegs of Powder. | Tons per Keg. | Cost to Miner per Keg. |
|---|---|---|---|---|
| Clay | 1,222,431 | 49,029 | 25 | $1 75 |
| Daviess | 191,159 | 12,374 | 16 | 1 75 |
| Fountain | Not reported | ..... | ..... | ..... |
| Gibson | 46,700 | 1,599 | 29 | 1 75 |
| Greene | 2,226,789 | 51,663 | 43 | 1 75 |
| Knox | 137,949 | 7,836 | 18 | 1 75 |
| Parke | 922,994 | 40,807 | 23 | 1 75 |
| Pike | 484,258 | 20,557 | 24 | 1 75 |
| Perry | 11,120 | 701 | 16 | 1 75 |
| Sullivan | 1,553,338 | 23,526 | 65 | 1 75 |
| Vanderburgh | 204,648 | 6,880 | 30 | 1 75 |
| Vermillion | 942,165 | 32,796 | 29 | 1 75 |
| Vigo | 1,716,726 | 71,669 | 24 | 1 75 |
| Warrick | 315,641 | 8,383 | 38 | 1 75 |
| Total | 9,992,553 | 327,820 | 30 | $573,685 00 |

## TABLE,

*Showing Per Cent. in Gross Tons Produced, Gross Wages Paid, and Total Number of Persons Employed at Indiana Mines for Year 1903 over 1901 and 1902.*

| | 1901 | 1902 | 1903 | Per Cent. Gained Over 1901. | Per Cent. Gained Over 1902. |
|---|---|---|---|---|---|
| Total Tonnage Produced | 7,019,203 | 8,763,197 | 9,992,553 | 42.3 | 14.02 |
| Total Wages Paid | $5,680,539 86 | $7,078,913 12 | $9,149,572 12 | 61.08 | 29.2 |
| Total Employes | 12,096 | 13,139 | 15,128 | 25.06 | 13.14 |

# TABLE,

*Showing Number of Miners, Machine Runners and Helpers, Loaders, Inside Day and Monthly Men, and Persons Employed Outside; Total Number of Employes at Each Mine, Number of Days Worked and Number of Mules Used; Totals by Counties, Expenditure for Improvements and Number of Kegs of Powder Used.*

## CLAY COUNTY.

| NAME OF MINE. | Pick Miners. | Machine Runners and Helpers. | Loaders. | Inside Day and Monthly Men. | Outside Day Men. | Total Employes. | Days Worked. | Mules Used. | Fatal Accidents. | Improvements. | Number Kegs of Powder. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Brazil Block No. 1 | 23 | 4 | 8 | 20 | 7 | 62 | 288 | 7 | 1 | ..... | 1,088 |
| Brazil Block No. 8 | 17 | 12 | 31 | 34 | 11 | 105 | 261 | 10 | ..... | ..... | 2,597 |
| Diamond No. 6 | 16 | 10 | 33 | 32 | 12 | 103 | 248 | 12 | ..... | ..... | 892 |
| Brazil Block No. 11 | 20 | 2 | 4 | 10 | 4 | 40 | 124 | 3 | ..... | ..... | 1,120 |
| Continental No. 1 | 26 | ..... | ..... | 8 | 5 | 39 | 147 | 2 | ..... | $336 00 | ..... ..... |
| Gart No 5 | 34 | ..... | ..... | 4 | 5 | 43 | 17 | 6 | ..... | ..... | ..... |
| Gart No. 7 | 60 | ..... | ..... | 15 | 9 | 84 | 200 | 7 | 1 | 5,035 65 | 609 |
| Gart No. 10 | 14 | 4 | 15 | 14 | 7 | 54 | 19 | 7 | ..... | ..... | 1,228 |
| Rebstock | 27 | ..... | ..... | 3 | 6 | 36 | 24 | 1 | ..... | ..... | 320 |
| Briar Hill | 6 | 8 | 9 | 8 | 6 | 37 | 16 | 5 | ..... | ..... | ..... |
| Cloverland No. 1 | 136 | ..... | ..... | 45 | 15 | 196 | 163 | 17 | ..... | ..... | 5,050 |
| Fair View | 18 | ..... | ..... | 9 | 5 | 32 | 50 | 3 | ..... | ..... | 750 |
| Lawrence No. 6 | 65 | ..... | ..... | 8 | 6 | 79 | 188 | 4 | ..... | ..... | 1,222 |
| Lawrence No. 7 | 84 | ..... | ..... | 29 | 9 | 122 | 281 | 10 | ..... | ..... | 3,642 |
| Cornwell | 67 | ..... | ..... | 11 | 6 | 84 | 228 | 7 | 1 | ..... | 1,750 |
| Crawford No. 3 | 41 | ..... | ..... | 6 | 4 | 51 | 130 | 3 | ..... | ..... | 322 |
| Crawford No. 2 | 53 | ..... | ..... | 10 | 5 | 68 | 278 | 4 | ..... | ..... | 1,995 |
| Crawford No. 5 | 52 | ..... | ..... | 11 | 5 | 68 | 255 | 4 | ..... | ..... | 2,420 |
| Crawford No. 6 | 46 | ..... | ..... | 11 | 5 | 62 | 203 | 3 | ..... | ..... | 2,324 |
| Crawford No. 7 | 60 | ..... | ..... | 12 | 6 | 78 | 284 | 4 | ..... | ..... | 1,885 |
| Eureka No. 3 | 22 | ..... | ..... | 6 | 4 | 32 | 217 | 4 | ..... | ..... | 607 |
| Fortner | 43 | ..... | ..... | 9 | 4 | 56 | 174 | 5 | ..... | ..... | 1,481 |
| Klondyke | 90 | ..... | ..... | 20 | 9 | 119 | 228 | 11 | 1 | ..... | 2,037 |
| Gifford No. 1 | 40 | 12 | 31 | 25 | 10 | 118 | 169 | 9 | ..... | 8,313 41 | 3,050 |
| Gifford No. 2 | 90 | 12 | 33 | 22 | 12 | 169 | 224 | 16 | 1 | ..... | 5,000 |
| Glen | 78 | ..... | ..... | 10 | 7 | 95 | 216 | 5 | ..... | ..... | 3,565 |
| Pratt | 27 | ..... | ..... | 7 | 6 | 40 | 105 | 5 | ..... | ..... | 510 |

*Table Showing Number of Miners, Machine Runners and Helpers, etc.*—Continued.

CLAY COUNTY—Continued.

| NAME OF MINE. | Pick Miners. | Machine Runners and Helpers. | Loaders. | Inside Day and Monthly Men. | Outside Day Men. | Total Employes. | Days Worked. | Mules Used. | Fatal Accidents. | Improvements. | Number Kegs of Powder. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Monarch | 16 | ..... | ..... | 19 | 2 | 37 | 267 | 2 | ..... | ..... | ..... |
| Pearl | 95 | ..... | ..... | 16 | 8 | 119 | 220 | 7 | ..... | ..... | 2,713 |
| Lewis | ..... | 4 | 10 | 1 | 4 | 19 | 52 | 1 | ..... | ..... | 125 |
| Silverwood No. 3 | 32 | ..... | ..... | 12 | 9 | 53 | 183 | 7 | ..... | ..... | ..... |
| Cloverland No. 2 | 47 | ..... | ..... | 5 | 4 | 56 | 77 | 2 | ..... | ..... | 727 |
| Total | 1,445 | 68 | 174 | 452 | 217 | 2,356 | 5,536 | 193 | 5 | $13,685 06 | 49,029 |

DAVIESS COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cabel No. 4 | 20 | ..... | ..... | 4 | 6 | 30 | 57 | 3 | ..... | ..... | ..... |
| Cabel No. 9 | 50 | ..... | ..... | 15 | 7 | 72 | 199 | 6 | ..... | ..... | 1,534 |
| Hoosier No. 4 | 12 | ..... | ..... | 3 | 2 | 17 | 30 | ..... | ..... | ..... | ..... |
| Montgomery No. 2 | 34 | ..... | ..... | 11 | 6 | 51 | 267 | 5 | ..... | ..... | 2,224 |
| Montgomery No. 3 | 123 | ..... | ..... | 28 | 11 | 162 | 256 | 17 | ..... | ..... | 5,916 |
| Mutual | 52 | ..... | ..... | 9 | 7 | 68 | 210 | 7 | 1 | $1,600 00 | 2,400 |
| Union | 26 | ..... | ..... | 4 | 3 | 33 | 162 | 2 | ..... | 600 00 | ..... |
| Mandabach | 12 | ..... | ..... | 2 | 3 | 17 | 53 | 2 | 1 | ..... | 300 |
| Total | 329 | ..... | ..... | 76 | 45 | 450 | 1,234 | 42 | 2 | $2,200 00 | 12,374 |

FOUNTAIN COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diamond | 8 | ..... | ..... | 2 | 2 | 12 | 48 | 1 | ..... | $30 00 | ..... |
| Rush | 42 | ..... | ..... | 8 | 6 | 56 | 23 | 2 | 1 | 3,100 00 | ..... |
| Silverwood | 16 | ..... | ..... | 1 | 8 | 25 | 26 | 1 | ..... | ..... | ..... |
| Total | 66 | ..... | ..... | 11 | 16 | 93 | 97 | 4 | 1 | $3,130 00 | ..... |

## GIBSON COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Oswald | 54 | ..... | ..... | 30 | 17 | 101 | 140 | 12 | ..... | $3,554 05 | 1,599 |
| Total | 54 | ..... | ..... | 30 | 17 | 101 | 140 | 12 | ..... | $3,554 05 | 1,599 |

## GREENE COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Black Creek | 65 | 10 | 50 | 30 | 9 | 164 | 183 | 16 | 2 | ..... | 3,259 |
| Island No. 1 | 48 | 14 | 32 | 42 | 13 | 149 | 218 | 16 | ..... | ..... | 2,136 |
| Island No. 2 | 50 | 34 | 50 | 40 | 27 | 201 | 215 | 15 | ..... | ..... | 2,280 |
| Island No. 3 | 83 | ..... | ..... | 23 | 10 | 116 | 216 | 13 | ..... | ..... | 2,576 |
| Gilmour | 15 | 16 | 90 | 42 | 15 | 178 | 206 | 19 | ..... | ..... | 1,380 |
| Hoosier No. 1 | 6 | 4 | 22 | 6 | 5 | 43 | 239 | 3 | ..... | ..... | 514 |
| Island Valley No. 3 | 120 | ..... | ..... | 32 | 12 | 164 | 182 | 18 | ..... | ..... | 4,515 |
| Island Valley No. 2 | 43 | ..... | ..... | 10 | 8 | 61 | 209 | 5 | ..... | $1,381 29 | 1,252 |
| South Linton | 150 | ..... | ..... | 31 | 9 | 190 | 206 | 17 | ..... | ..... | 5,456 |
| Midland | 12 | 12 | 60 | 25 | 10 | 119 | 190 | 9 | 1 | ..... | 1,200 |
| Vulcan | 17 | ..... | ..... | 3 | 6 | 26 | 81 | 1 | ..... | 310 00 | 400 |
| Summitt No. 2 | 18 | 16 | 92 | 54 | 8 | 188 | 190 | 18 | ..... | ..... | 1,705 |
| Templeton | 93 | ..... | ..... | 21 | 11 | 125 | 280 | 13 | 1 | ..... | 3,600 |
| Victoria | 164 | ..... | ..... | 30 | 13 | 207 | 254 | 11 | 1 | ..... | 8,497 |
| Glenburn | 35 | 14 | 73 | 47 | 14 | 183 | 197 | 20 | 1 | ..... | 2,000 |
| Antioch | 78 | ..... | ..... | 36 | 11 | 125 | 288 | 7 | 2 | 12,724 76 | 2,707 |
| Tower Hill | 12 | 8 | 32 | 9 | 10 | 71 | 223 | 3 | ..... | 2,576 55 | 1,062 |
| Green Valley | ..... | 14 | 60 | 21 | 10 | 105 | 182 | 8 | 1 | ..... | 1,044 |
| Lattis Creek No. 1 | ..... | 16 | 72 | 38 | 20 | 146 | 216 | 9 | ..... | 600 00 | 1,600 |
| Atlas No. 1 | 21 | 10 | 45 | 18 | 10 | 104 | 233 | 9 | ..... | ..... | 1,444 |
| Fry | 25 | ..... | ..... | 6 | 3 | 34 | ..... | 2 | ..... | 2,336 39 | 1,200 |
| Letsinger | 16 | 8 | 18 | 5 | 9 | 56 | ..... | 3 | 1 | 19,500 00 | 500 |
| North West | 10 | 8 | 26 | 21 | 11 | 76 | 172 | 6 | 1 | 3,677 13 | 840 |
| Twin | ..... | 6 | 11 | 3 | 7 | 27 | 70 | 2 | ..... | ..... | ..... |
| Island No. 5 | 16 | ..... | ..... | 10 | 6 | 32 | 49 | 2 | ..... | ..... | 385 |
| Atlas No. 2 | 15 | 6 | 18 | 7 | 8 | 54 | 39 | 3 | ..... | ..... | 111 |
| Total | 1,112 | 196 | 751 | 610 | 275 | 2,944 | 4,512 | 248 | 11 | $43,106 12 | 51,663 |

*Table Showing Number of Miners, Machine Runners and Helpers, etc.*—Continued.

KNOX COUNTY.

| NAME OF MINE. | Pick Miners. | Machine Runners and Helpers. | Loaders. | Inside Day and Monthly Men. | Outside Day Men. | Total Employes. | Days Worked. | Mules Used. | Fatal Accidents. | Improvements. | Number Kegs of Powder. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bicknell | 45 | ..... | ..... | 12 | 10 | 67 | 202 | 8 | ..... | ..... | 3,496 |
| Edwardsport | 20 | ..... | ..... | 7 | 5 | 32 | 69 | 4 | ..... | $50 00 | ..... |
| Knox | 51 | ..... | ..... | 13 | 7 | 71 | 172 | 7 | 2 | ..... | 3,000 |
| Lynn | 32 | ..... | ..... | 6 | 6 | 44 | 100 | 5 | ..... | 800 00 | 840 |
| Prospect Hill | 18 | ..... | ..... | 5 | 3 | 26 | 202 | 3 | ..... | ..... | 500 |
| Total | 166 | ..... | ..... | 43 | 31 | 240 | 745 | 27 | 2 | $850 00 | 7,836 |

PARKE COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C. B. Harrison | 6 | ..... | ..... | 1 | 1 | 8 | 20 | 2 | ..... | $40 00 | 232 |
| W. P. Harrison | Not re | ported. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 800 00 | 640 |
| Brazil Block No. 12 | 20 | 18 | 50 | 40 | 14 | 142 | 265 | 16 | ..... | ..... | 1,492 |
| Cox No. 3 | 77 | ..... | ..... | 25 | 14 | 116 | 260 | 10 | 1 | 4,896 46 | 3,065 |
| Lucia | 57 | ..... | ..... | 18 | 7 | 82 | 202 | 12 | 2 | 600 00 | 2,568 |
| Mecca No. 1 | 32 | ..... | ..... | 17 | 8 | 57 | 202 | 13 | 1 | ..... | 1,778 |
| New Century | Not re | ported. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Lyford No. 1 | ..... | 12 | 40 | 31 | 15 | 98 | 175 | 7 | ..... | 15,871 00 | 1,341 |
| Mary | 17 | 14 | 45 | 27 | 9 | 112 | 249 | 8 | 1 | 2,200 53 | 2,295 |
| McIntosh No. 3 | 33 | ..... | ..... | 10 | 5 | 48 | 271 | 3 | ..... | ..... | ..... |
| Superior No. 1 | 128 | ..... | ..... | 20 | 8 | 156 | 227 | 9 | 1 | ..... | 4,971 |
| Superior No. 2 | 83 | ..... | ..... | 25 | 8 | 116 | 277 | 11 | 1 | ..... | 3,926 |
| Superior No. 3 | 85 | ..... | ..... | 13 | 7 | 105 | 177 | 5 | 1 | ..... | 2,502 |
| Minshal No. 1 | 141 | ..... | ..... | 40 | 10 | 191 | 260 | 16 | ..... | 1,411 68 | 6,064 |
| Pan American | 140 | ..... | ..... | 21 | 11 | 172 | 211 | 8 | ..... | ..... | 3,443 |
| Brazil Block No. 9 | 93 | ..... | ..... | 31 | 9 | 133 | 178 | 9 | ..... | ..... | 1,743 |
| Raccoon | 27 | ..... | ..... | 5 | 5 | 37 | 238 | 3 | 2 | 62 28 | 1,628 |
| Park No. 11 | 19 | 12 | 11 | 8 | 7 | 57 | 180 | 3 | ..... | ..... | 1,301 |
| Minshal No. 2 | 17 | ..... | ..... | 3 | 4 | 24 | 27 | 1 | ..... | ..... | 41 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Crawford No. 10 | Not reported. | | | | | | | | | | 109 |
| Crawford No. 8 | Not reported. | | | | | | | | | | 344 |
| Mecca No. 4 | | | | | | | | | | | 1,324 |
| Total | 975 | 56 | 146 | 335 | 142 | 1,654 | 3,419 | 136 | 10 | $25,881 95 | 40,807 |

## PIKE COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Massey | 28 | | | 5 | 3 | 36 | 195 | 3 | | $2,243 15 | 1,200 |
| Aberdeen | 30 | | | 8 | 6 | 44 | 204 | 5 | | 1,121 00 | 1,200 |
| Ayrshire No. 3 | 61 | | | 21 | 9 | 91 | 156 | 17 | | | 6,944 |
| Ayrshire No. 4 | 85 | | | 26 | 20 | 131 | 140 | 10 | | 2,506 60 | |
| Ayrshire No. 5 | Not reported. | | | | | | | | | 2,250 09 | |
| Blackburn | 48 | | | 12 | 8 | 68 | 123 | 8 | | | 1,708 |
| Hartwell | 90 | | | 14 | 18 | 122 | 178 | 11 | | 3,049 87 | 2,730 |
| Littles | 122 | | | 35 | 11 | 168 | 176 | 20 | 1 | | 4,220 |
| Rogers | 20 | | | 5 | 1 | 26 | 27 | 2 | | | 106 |
| Petersburg | 35 | | | 16 | 7 | 58 | 159 | 6 | | | 1,549 |
| Carbon | 17 | | | 6 | 4 | 27 | 226 | 8 | | 1,650 00 | 900 |
| Winslow | 80 | | | 22 | 15 | 117 | 184 | 12 | | 532 98 | |
| Total | 616 | | | 170 | 102 | 888 | 1,768 | 97 | 1 | $13,353 69 | 20,557 |

## PERRY COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Troy | 20 | | | 3 | 3 | 26 | 205 | 2 | | $480 00 | 701 |
| Total | 20 | | | 3 | 3 | 26 | 205 | 2 | | $480 00 | 701 |

## SULLIVAN COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lablanch | 8 | | | 13 | 19 | 40 | 21 | 1 | | | |
| Bunker Hill | 19 | 4 | 24 | 20 | 10 | 77 | 193 | 12 | | $1,354 00 | 1,809 |
| Caledonia | | 12 | 54 | 33 | 13 | 112 | 227 | 10 | | 18,774 00 | 2,003 |
| Dugger | 10 | 8 | 44 | 35 | 15 | 112 | 213 | 14 | 1 | | 942 |
| Green Hill | | 8 | 45 | 17 | 9 | 79 | 159 | 8 | 1 | 341 71 | 700 |
| Hymera No. 1 | 20 | 12 | 105 | 35 | 25 | 197 | 207 | 15 | 1 | | 2,142 |
| West Linton | Not reported. | | | | | | | | | 2,800 00 | |
| Jackson Hill No. 2 | | 18 | 108 | 48 | 16 | 190 | 233 | 22 | 1 | | 1,618 |
| Phoenix No. 1 | 18 | 16 | 40 | 27 | 17 | 118 | 216 | 10 | | | |

*Table Showing Number of Miners, Machine Runners and Helpers, etc.*—Continued.

SULLIVAN COUNTY—Continued.

| NAME OF MINE. | Pick Miners. | Machine Runners and Helpers. | Loaders. | Inside Day and Monthly Men. | Outside Day Men. | Total Employes. | Days Worked. | Mules Used. | Fatal Accidents. | Improvements. | Number Kegs of Powder. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Phoenix No. 3 | 15 | ..... | ..... | 4 | 3 | 22 | 203 | 3 | ..... | ..... | 2,062 |
| Phoenix No. 5 | 37 | 6 | 6 | 12 | 9 | 70 | 84 | 6 | 1 | ..... | ..... |
| Shelburn | 4 | 4 | 14 | 9 | 9 | 40 | 183 | 6 | 1 | $3,850 00 | ..... |
| Star City | ..... | 16 | 84 | 52 | 24 | 176 | 212 | 14 | 1 | ..... | 1,551 |
| White Ash | 51 | ..... | ..... | 11 | 7 | 69 | 217 | 5 | ..... | 2,130 93 | 1,988 |
| Freeman | 30 | ..... | ..... | 7 | 5 | 42 | 77 | 4 | ..... | 1,211 00 | 813 |
| Sun Flower | 1 | 12 | 73 | 23 | 10 | 119 | 208 | 8 | ..... | ..... | 1,200 |
| Glendora | 2 | 16 | 103 | 37 | 19 | 177 | 200 | 10 | ..... | ..... | 2,312 |
| Hymera No. 2 | 12 | 12 | 85 | 20 | 15 | 144 | 191 | 11 | 1 | ..... | 2,397 |
| Wilfred No. 1 | ..... | 12 | 70 | 27 | 14 | 123 | 219 | 7 | ..... | ..... | 1,618 |
| Little Giant | ..... | 6 | 28 | 18 | 10 | 62 | 125 | 3 | ..... | ..... | 221 |
| Cummins | 8 | 10 | 17 | 15 | 15 | 65 | 103 | 4 | ..... | ..... | ..... |
| Citizens | 12 | ..... | ..... | 4 | 5 | 21 | 24 | 2 | ..... | ..... | ..... |
| Mildred | ..... | 4 | 6 | 1 | 4 | 15 | 50 | 1 | ..... | ..... | 100 |
| Island No. 4 | 20 | ..... | ..... | 2 | 6 | 28 | 22 | 2 | 1 | ..... | 60 |
| Mammouth Vein | 8 | 2 | 2 | 6 | 4 | 22 | 19 | 1 | ..... | ..... | ..... |
| Total | 275 | 178 | 908 | 476 | 283 | 2,120 | 3,606 | 177 | 9 | $30,461 64 | 23,526 |

VANDERBURGH COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Diamond | 35 | ..... | ..... | 6 | 6 | 47 | 260 | 3 | ..... | ..... | ..... |
| First Avenue | 22 | ..... | ..... | 5 | 7 | 84 | 92 | 2 | ..... | ..... | 732 |
| Ingleside | Not reported. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Sunnyside | 61 | ..... | ..... | 17 | 10 | 88 | 188 | 11 | 3 | ..... | 2,032 |
| Union | 30 | ..... | ..... | 7 | 7 | 44 | 203 | 4 | ..... | $500 00 | 144 |
| Unity | 74 | ..... | ..... | 12 | 10 | 96 | 278 | 9 | ..... | ..... | 3,972 |
| Total | 222 | ..... | ..... | 47 | 40 | 309 | 1,021 | 29 | 3 | $500 00 | 6,880 |

## VERMILLION COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bruilettes Creek No. 3 | 91 | ..... | ..... | 22 | 8 | 121 | 183 | 13 | ..... | ..... | 7,233 |
| Bruilettes Creek No. 5 | 115 | ..... | ..... | 25 | 10 | 150 | 131 | 16 | 2 | ..... | ..... |
| Buckeye | 47 | ..... | ..... | 17 | 18 | 72 | 181 | 7 | ..... | ..... | ..... |
| Cayuga | 15 | ..... | ..... | 4 | 3 | 22 | 235 | 2 | ..... | $331 60 | 700 |
| Crown Hill No. 1 | 133 | ..... | ..... | 22 | 10 | 165 | 222 | 12 | ..... | 11,685 00 | 7,895 |
| Oak Hill | 141 | ..... | ..... | 37 | 11 | 189 | 192 | 16 | 1 | 3,072 80 | 9,301 |
| Prince | 155 | ..... | ..... | 34 | 10 | 199 | 216 | 14 | 1 | 1,474 56 | 1,600 |
| Willow Grove | 70 | ..... | ..... | 10 | 7 | 87 | 172 | 6 | ..... | 7,344 15 | 5,796 |
| Crown Hill No. 2 | Not reported. | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | 271 |
| Total | 767 | ..... | ..... | 171 | 67 | 1,005 | 1,532 | 86 | 4 | $23,908 11 | 32,796 |

## VIGO COUNTY.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atherton | ..... | 8 | 35 | 8 | 9 | 60 | 258 | 3 | ..... | ..... | ..... |
| Rhoades | 33 | ..... | ..... | 17 | 8 | 58 | 49 | 3 | ..... | ..... | ..... |
| Brick Works | 12 | ..... | ..... | 4 | 2 | 18 | 140 | 2 | ..... | ..... | 600 |
| Chicago No. 6 | 78 | ..... | ..... | 18 | 8 | 104 | 154 | 9 | ..... | $250 69 | 1,200 |
| Diamond | 120 | ..... | ..... | 40 | 13 | 173 | 178 | 16 | ..... | ..... | 4,000 |
| Peerless | 70 | ..... | ..... | 20 | 8 | 98 | 29 | 11 | ..... | ..... | 2,575 |
| Lawton | 113 | 4 | 3 | 28 | 11 | 159 | 205 | 11 | ..... | ..... | 3,660 |
| Union | 73 | ..... | ..... | 24 | 12 | 109 | 241 | 13 | ..... | ..... | 2,330 |
| Ehrlich | 21 | ..... | ..... | 11 | 5 | 37 | 259 | 3 | 1 | ..... | 923 |
| Grant No. 2 | 110 | ..... | ..... | 38 | 11 | 159 | 170 | 18 | ..... | 216 00 | 4,947 |
| Glen Oak | 50 | 12 | 67 | 51 | 17 | 137 | 242 | 30 | 1 | ..... | 3,899 |
| Hector | 60 | ..... | ..... | 18 | 9 | 87 | 248 | 8 | ..... | 250 00 | 3,035 |
| Klondyke | 93 | ..... | ..... | 17 | 10 | 120 | 235 | 12 | ..... | ..... | 3,621 |
| Miami No. 1 | 157 | ..... | ..... | 23 | 10 | 190 | 216 | 13 | ..... | ..... | 4,973 |
| Nickle Plate | 40 | ..... | ..... | 13 | 9 | 62 | 146 | 7 | 1 | ..... | ..... |
| Park No. 10 | 50 | 30 | 40 | 47 | 17 | 184 | 227 | 15 | ..... | ..... | 2,830 |
| Ray | 70 | ..... | ..... | 13 | 6 | 89 | 42 | 7 | ..... | ..... | ..... |
| Redbird | 41 | ..... | ..... | 7 | 4 | 52 | 283 | 3 | ..... | ..... | 2,145 |
| Rosebud No. 2 | 128 | ..... | ..... | 30 | 9 | 167 | 232 | 9 | ..... | ..... | 4,220 |
| Royal No. 1 | 95 | ..... | ..... | 20 | 12 | 127 | 228 | 8 | ..... | ..... | 4,414 |
| Larimer | 22 | ..... | ..... | 5 | 5 | 32 | 44 | 2 | 1 | ..... | 717 |
| Broadhurst | 50 | ..... | ..... | 8 | 7 | 65 | 270 | 4 | ..... | ..... | 3,280 |
| Miami No. 2 | 28 | ..... | ..... | 6 | 4 | 38 | 142 | 2 | ..... | ..... | 778 |
| Deep Vein | 40 | ..... | ..... | 12 | 6 | 58 | 165 | 3 | ..... | ..... | 1,860 |
| Greenfield No. 1 | 27 | ..... | ..... | 5 | 5 | 37 | 203 | 2 | ..... | ..... | 1,925 |
| Lost Creek | 36 | ..... | ..... | 8 | 6 | 50 | 45 | 4 | ..... | ..... | 625 |
| Sugar Creek | 12 | ..... | ..... | 7 | 6 | 25 | 24 | 1 | ..... | ..... | ..... |
| Total | 1,629 | 54 | 145 | 498 | 229 | 2,555 | 4,665 | 219 | 4 | $585 57 | 71,669 |

*Table Showing Number of Miners, Machine Runners and Helpers, etc.*—Continued.

WARRICK COUNTY.

| NAME OF MINE. | Pick Miners. | Machine Runners and Helpers. | Loaders. | Inside Day and Monthly Men. | Outside Day Men. | Total Employes. | Days Worked. | Mules Used. | Fatal Accidents. | Improvements. | Number Kegs of Powder. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Air Line | 21 | ..... | ..... | 4 | 3 | 28 | 247 | 3 | 1 | $1,525 00 | ..... |
| Big Four | ..... | 12 | 42 | 15 | 12 | 81 | 244 | 7 | ..... | 2,951 16 | 1,540 |
| Big Vein No. 3 | 13 | 16 | 39 | 10 | 9 | 87 | 155 | 4 | 1 | ..... | 1,238 |
| Caledonia | 13 | ..... | ..... | 3 | 3 | 19 | 210 | 3 | ..... | 26 00 | 610 |
| Chandler | 24 | ..... | ..... | 7 | 3 | 34 | 186 | 3 | ..... | 1,645 75 | 920 |
| DeForrest | 17 | ..... | ..... | 3 | 3 | 23 | 127 | 2 | ..... | 227 86 | 1,025 |
| Star No. 1 | 44 | ..... | ..... | 9 | 10 | 63 | 130 | 9 | 1 | ..... | 2,050 |
| Electric | ..... | 8 | 27 | 8 | 9 | 52 | 149 | 4 | ..... | ..... | 1,000 |
| **Total** | 132 | 36 | 108 | 59 | 52 | 387 | 1,448 | 35 | 3 | $6,375 77 | 8,383 |
| **Grand total** | 7,808 | 588 | 2,232 | 2,981 | 1,519 | 15,128 | 29,928 | 1,300 | 54 | $168,071 96 | 327,820 |

# TABLE.

## MACHINE MINES.

*Showing by Counties the Name of Mines, Number and Kind of Machines, Tons of Coal Mined, Number Miners Employed, Average Tons per Miner.*

### CLAY COUNTY BLOCK COAL MINES.

| MINE. | KIND OF MACHINES. | | | Tons Produced. | Number of Miners Employed. | Average Tons per Miner. | Average Tons per Machine. |
|---|---|---|---|---|---|---|---|
| | Compressed Air Puncher. | Electric Chain. | Total Number Machines. | | | | |
| Brazil Block No. 1 | ..... | 9 | 9 | 12 094 | 12 | 1,008 | 1,344 |
| Brazil Block No. 8 | ..... | 6 | 6 | 35,110 | 43 | 812 | 58,578 |
| Brazil Block No. 1 | ..... | 2 | 2 | 1,673 | 16 | 105 | 836 |
| Diamond No. 5 | ..... | 5 | 5 | 44,009 | 43 | 1,023 | 8,802 |
| Gart No. 10 | ..... | 3 | 3 | 27,447 | 19 | 1,445 | 9,149 |
| Total General Average | ..... | 24 | 24 | 120,333 | 133 | 980 | 5,013 |

### PARKE COUNTY BLOCK COAL MINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Brazil Block No. 12 | ..... | 12 | 12 | 55,875 | 6[illegible] | 821 | 4,656 |
| Mary | ..... | 7 | 7 | 11,222 | 59 | 190 | 1,603 |
| Total General Average | ..... | 19 | 19 | 67,097 | 127 | 528 | 3,531 |

### CLAY COUNTY BITUMINOUS MINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Gifford No. 1 | ..... | 6 | 6 | 27,958 | 43 | 650 | 4,659 |
| Gifford No. 3 | ..... | 6 | 6 | 35,072 | 45 | 779 | 5,845 |
| Total General Average | ..... | 12 | 12 | 63,030 | 88 | 716 | 5,252 |

### GREENE COUNTY BITUMINOUS MINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Black Creek | ..... | 5 | 5 | 80,111 | 60 | 1,201 | 16,022 |
| Island No. 1 | 8 | ..... | 8 | 67,149 | 46 | 1,460 | 8,393 |
| Island No. 2 | 18 | ..... | 18 | 110.774 | 84 | 1,318 | 6,154 |
| Gilmour | ..... | 8 | 8 | 136,024 | 106 | 1,283 | 17,003 |
| Hoosier No 1 | ..... | 2 | 2 | 20,925 | 26 | 804 | 10,462 |
| Midland | ..... | 6 | 6 | 100,185 | 72 | 1,391 | 16,697 |
| Summit No. 2 | ..... | 9 | 9 | 147,631 | 108 | 1,367 | 16,403 |
| Glenburn | ..... | 7 | 7 | 99,215 | 87 | 1,140 | 14,173 |
| Antioch | ..... | 6 | 6 | 31,732 | 50 | 634 | 5,288 |
| Green Valley | ..... | 7 | 7 | 86,386 | 74 | 1,167 | 12,340 |
| Lattis Creek | ..... | 8 | 8 | 108,961 | 88 | 1,238 | 13,745 |
| Atlas No. 1 | ..... | 5 | 5 | 75,478 | 55 | 1,372 | 15,095 |
| Letsinger | 4 | ..... | 4 | 18,325 | 26 | 705 | 4,581 |
| North West No. 1 | ..... | 4 | 4 | 26,177 | 34 | 770 | 6,544 |
| Twin | ..... | 3 | 3 | 2,615 | 17 | 153 | 871 |
| Atlas No. 2 | ..... | 2 | 2 | 4,892 | 34 | 149 | 2,446 |
| Tower Hill | ..... | 5 | 5 | 46,378 | 40 | 1,159 | 9,275 |
| Total General average | 30 | 77 | 107 | 1,162,958 | 1,007 | 1,155 | 11,896 |

## MACHINE MINES—Continued.

### PARKE COUNTY BITUMINOUS MINES.

| MINE. | Kind of Machines. | | | Tons Produced. | Number of Miners Employed. | Average Tons per Miner. | Average Tons per Machine. |
|---|---|---|---|---|---|---|---|
| | Compressed Air Puncher. | Electric Chain. | Total Number Machines. | | | | |
| Lyford No. 1 | ..... | 6 | 6 | 22,080 | 52 | 424 | 3,680 |
| Parke No. 1 | 6 | ..... | 6 | 25,749 | 23 | 1,119 | 4,291 |
| Total General average | 6 | 6 | 12 | 47,829 | 75 | 638 | 3,985 |

### SULLIVAN COUNTY BITUMINOUS MINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Bunker Hill | ..... | 4 | 4 | 28,836 | 28 | 1,022 | 7,209 |
| Caledonia | ..... | 8 | 8 | 36,956 | 66 | 560 | 4,618 |
| Dugger | ..... | 5 | 5 | 68,410 | 52 | 1,315 | 13,682 |
| Green Hill | ..... | 4 | 4 | 40,246 | 53 | 759 | 10,061 |
| Hymera No. 1 | ..... | 8 | 8 | 156,392 | 117 | 1,336 | 19,549 |
| Jackson Hill No. 2 | ..... | 9 | 9 | 196,415 | 126 | 1,559 | 21,824 |
| Phoenix No. 3 | 9 | ..... | ..... | 128,036 | 56 | 2,286 | 14,670 |
| Phoenix No. 5 | 3 | ..... | ..... | 17,416 | 12 | 1,451 | 5,805 |
| Shelburn | ..... | 2 | 2 | 15,834 | 18 | 879 | 7,917 |
| Star City | ..... | 8 | 8 | 105,739 | 100 | 1,057 | 13,217 |
| Sun Flower | ..... | 6 | 6 | 139,832 | 85 | 1,527 | 23,305 |
| Glendora | ..... | 8 | 8 | 163,768 | 119 | 1,376 | 20,471 |
| Hymera No. 2 | ..... | 8 | 8 | 152,770 | 97 | 1,575 | 19,096 |
| Wilfred | ..... | 8 | 8 | 130,846 | 82 | 1,595 | 16,355 |
| West Linton | ..... | 1 | 1 | 280 | 10 | 28 | 280 |
| Cummins | 5 | ..... | 5 | 2,000 | 27 | 7 | 400 |
| Mildred | ..... | 2 | 2 | 1,745 | 10 | 174 | 872 |
| Total General Average | 17 | 81 | 98 | 1,385 548 | 1,133 | 1,222 | 14,138 |

### VIGO COUNTY BITUMINOUS COAL MINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Atherton | ..... | 4 | 4 | 39,713 | 43 | 900 | 9,928 |
| Lawton | ..... | 2 | 2 | 3,920 | 7 | 531 | 1,960 |
| Glen Oak | ..... | 6 | 6 | 165,715 | 79 | 2,090 | 27 519 |
| Parke No. 10 | 15 | ..... | 15 | 146,988 | 70 | 2,099 | 9,799 |
| Total General Average | 15 | 12 | 27 | 355,736 | 199 | 1,285 | 29,645 |

### WARRICK COUNTY BITUMINOUS MINES.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Electric | ..... | 4 | 4 | 31,313 | 35 | 894 | 7,823 |
| Big Four | 6 | ..... | 6 | 74,003 | 54 | 1,345 | 12,334 |
| Big Vein | 8 | ..... | 8 | 96,231 | 55 | 1,749 | 12,029 |
| Total General Average | 14 | 4 | 18 | 201,547 | 144 | 1,399 | 11,141 |
| Grand Total | 82 | 235 | 317 | 3,404,078 | 2,820 | 1,207 | 10,738 |

NOTE.—Total pick miners, 7,808; total pick mine coal, 6,588,475 tons; average tons per miner, 843.

# TABLE,

*Showing Number of Miners, Total Wages of Miners and Average Wages Per Miner; Number of Inside Day and Monthly Men, Total Wages of Same, and Average Wages Per Man; Number of Outside Day and Monthly Men, Total Wages of Same, and Average Wages Per Employe, by Counties.*

| COUNTY. | Number of Miners. | Total Wages of Miners. | Average Earning Per Miner. | Number of Inside Day and Monthly Men. | Total Wages of Inside Day and Monthly Men. | Average Earning Per Inside Day and Monthly Men. | Total Wages of Persons Outside. | Number of Persons Outside. | Average Earning Per Outside Man. |
|---|---|---|---|---|---|---|---|---|---|
| Clay | 1,687 | $736,361 87 | $436 43 | 452 | $315,330 88 | $697 63 | $137,624 60 | 217 | $634 21 |
| Daviess | 329 | 131,413 05 | 451 11 | 76 | 42,503 13 | 559 12 | 21,525 94 | 45 | 478 30 |
| Fountain | 66 | 9,028 33 | 136 79 | 11 | 2,531 37 | 230 12 | 1,776 49 | 16 | 111 03 |
| Gibson | 54 | 24,854 19 | 460 26 | 30 | 15,609 54 | 520 31 | 10,769 33 | 17 | 633 48 |
| Greene | 2,059 | 1,228,519 74 | 596 65 | 610 | 427,766 47 | 602 89 | 231,759 18 | 275 | 842 76 |
| Knox | 166 | 78,796 92 | 474 68 | 43 | 28,118 42 | 654 38 | 15,676 27 | 31 | 505 68 |
| Parke | 1,177 | 699,901 77 | 593 79 | 335 | 268,874 31 | 802 60 | 119,728 18 | 142 | 843 15 |
| Perry | 20 | 7,412 74 | 370 63 | 3 | 2,069 69 | 689 89 | 1,632 92 | 3 | 544 30 |
| Pike | 616 | 292,045 31 | 474 09 | 170 | 105,706 67 | 621 80 | 52,180 01 | 102 | 511 55 |
| Sullivan | 1,361 | 768,741 31 | 563 36 | 476 | 322,156 76 | 676 79 | 175,538 92 | 283 | 620 31 |
| Vanderburgh | 222 | 134,192 28 | 604 46 | 47 | 35,535 68 | 756 07 | 23,007 82 | 40 | 575 12 |
| Vermillion | 767 | 538,829 07 | 702 51 | 171 | 140,071 21 | 819 12 | 69,547 49 | 67 | 1,038 02 |
| Vigo | 1,828 | 1,038,557 30 | 568 13 | 498 | 309,604 58 | 621 69 | 145,599 92 | 229 | 640 12 |
| Warrick | 276 | 157,026 13 | 569 58 | 59 | 34,661 66 | 587 60 | 22,793 96 | 52 | 438 30 |
| General Average | 10,628 | $6,017,021 20 | $566 14 | 2,981 | $2,085,116 28 | $699 67 | $1,047,434 64 | 1,519 | $689 54 |

NOTE.—Pick miners, machine runners and helpers and loaders are reported as miners.

# TABLE,

*Showing Price Paid Per Ton for Pick and Machine Mining, Inside Day Labor, Total Number of Employes, Total Production, Total Wages, Wages Per Year Per Employe, and Per Cent. of Gain or Loss Per Ton for Each Year from 1890 to 1903, Inclusive.*

| Year. | Block Mining. | | Bituminous Mining. | | Wages Inside Day Labor. | Total Number Employes. | Total Production. | Total Wages. | Wages Per Year Per Employe. | Per Cent. Gain. | Per Cent. Loss. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Price Pick Mining. | Price Machine Mining. | Price Pick Mining. | Price Machine Mining. | | | | | | | |
| 1890 | $0 75 | ..... | $0 70 | $0 34½ | $1 87½ | 6,550 | 3,791,211 | Not reported | ..... | ..... | ..... |
| 1891 | 75 | ..... | 70 | 34½ | 1 87½ | 6,975 | 3,819,600 | ..... | ..... | ..... | ..... |
| 1892 | 75 | ..... | 70 | 34½ | 1 90 | 7,600 | 4,408,471 | ..... | ..... | ..... | ..... |
| 1893 | 75 | ..... | 70 | 34½ | 1 90 | 7,431 | 4,358,897 | ..... | ..... | ..... | ..... |
| 1894 | 75 | ..... | 65 | 34½ | 1 90 | Not | reported. | ..... | ..... | ..... | 7½ |
| 1895 | 70 | ..... | 60 | 29½ | 1 75 | 7,885 | 4,202,084 | $1,852,500 00 | $234 93 | ..... | 7 8/13 |
| 1896 | 70 | ..... | 60 | 29½ | 1 75 | 7,112 | 4,068,124 | 1,750,000 00 | 246 06 | ..... | ..... |
| 1897 | 61 | ..... | 51 | 27⅞ | 1 52½ | 7,984 | 4,088,100 | 1,600,000 00 | 200 40 | ..... | 15 |
| 1898 | 76 | $0 57 | 66 | 30 | 1 75 | ..... | 5,140,920 | 1,182,500 00 | ..... | 29 1/17 | ..... |
| 1899 | 76 | 57 | 66 | 30 | 1 75 | 7,366 | 5,839,713 | 3,813,652 39 | 517 73 | ..... | ..... |
| 1900 | 90 | 68½ | 80 | 39 | 2 25 | 8,858 | 6,283,063 | 4,843,343 26 | 546 77 | 21 7/33 | ..... |
| 1901 | 90 | 68½ | 80 | 62 | 2 30 | 12,096 | 7,019,203 | 5,680,539 86 | 469 62 | ..... | ..... |
| 1902 | 90 | 68½ | 80 | 62 | 2 30 | 13,139 | 8,763,197 | 7,078,913 12 | 538 77 | ..... | ..... |
| 1903 | 1 00 | 78½ | 90 | 68½ | 2 56 | 15,128 | 9,992,553 | 9,149,572 12 | 604 81 | 12½ | ..... |

**Above Percentages are based on Pick Mining.**

**April 1st, 1900, Miners' Screens were reduced from 1½ inch mesh flat bar to 1¼ inch mesh acron bar, which amounted to 5 cts. advance per ton on mining.**

**Total reduction in price per ton from 1890 to 1897 amounted to 27½%.**

**Total gain 1903 over 1890, 35⅞%.**

**Total gain 1903 over 1897, 86%.**

## FATALITIES AND INJURIES.

During the year 1903 there were more accidents to mine employes, fatal, serious and minor, than in any of the previous years in the history of the mining industry of this State.

The monthly reports of mine bosses made to this Office show an aggregate of two hundred and seventy-six (276) accidents, classed as follows: Fatal, fifty-five (55); serious, one hundred and forty-five (145); and minor, seventy-seven (77), the causes of which are shown by the annexed table.

### TABLE,

*Exhibiting the Number of Casualties Arising from Different Causes, 1903.*

| CAUSE OF ACCIDENT. | Fatal. | Serious. | Minor. | Total. |
|---|---|---|---|---|
| Falling slate | 17 | 64 | 27 | 108 |
| Falling coal | 1 | 16 | 5 | 22 |
| Mine cars | 5 | 40 | 18 | 63 |
| Caught by cage | 3 | 3 | 5 | 11 |
| Kicked by mule | ..... | ..... | 2 | 2 |
| R. R. cars | 1 | ..... | 2 | 3 |
| Windy shots | 2 | 5 | ..... | 7 |
| Delayed shots | 4 | 1 | 1 | 6 |
| Premature shots | 5 | 7 | ..... | 12 |
| Smoke explosion | ..... | 10 | ..... | 5 |
| Shot blowing through pillar | 1 | 1 | 1 | 3 |
| Suffocated | 3 | ..... | ..... | 3 |
| Powder explosion | 4 | 2 | ..... | 6 |
| Explosion of kerosene | 1 | ..... | ..... | 1 |
| Gas explosion | 1 | 3 | ..... | 9 |
| Mining machine | ..... | ..... | 2 | 2 |
| Fell down shaft | 5 | ..... | ..... | 5 |
| Coal falling down shaft | ..... | 1 | 1 | 2 |
| Electric shock | 1 | ..... | ..... | 1 |
| Miscellaneous causes | ..... | 2 | 3 | 5 |
| Total | 55 | 145 | 77 | 277 |

An investigation of each of the above fatalities, as well as a greater part of the serious accidents, was made either by myself or one of my assistants, and, with one or two exceptions, i. e., where persons lived for some time after being injured, the investigation of the fatal accidents was made in conjunction with the coroner of the county in which the accident occurred.

### COMMENTS ON ACCIDENTS.

The increased number of casualties in 1903, as indicated by this report, is attributable, in some measure at least, to the number of new mines that have been opened, thus affording more

avenues of danger—there being more coal mined, necessitating the employment of a greater number of miners and other mine employes, also the use of more explosives, all of which are important factors in the history of mine accidents. The prime factors, however, is the use, or in a majority of cases the misuse, of these explosives.

In making an inspection of a mine recently, I overheard a miner remark, "that powder was cheaper than muscle." This seems to be the maxim of the average miner today, hence the increase in the number of mine accidents.

In our report for the year 1901, we made the statement that at least fifty per cent. of the mine accidents for that year were due either directly or indirectly to the use of powder; by smoke explosions caused by a number of heavy shots being fired simultaneously; by premature and delayed shots, also by windy or blown-out shots, the latter being caused by shots that were either misplaced or overcharged; all of which is very destructive to the safety of the miners and the property of the mine owners.

It will require but a brief review of the table of causes and the description of casualties occurring in 1903, to substantiate the fact that the above statement will more than hold good for that year.

Of the thirty-four fatalities, as shown by the table, nineteen (19), 35 7-10 per cent., were due directly to the use of powder and other explosives, while seventeen (17), or nearly 31½ per cent., were due to falling slate. Conservatively speaking, at least one-half of the latter number would have been avoided had the most ordinary precaution been taken in examining the roof after shots had been fired, and by resetting props which had been knocked down by coal thrown from such shots. All of such precautions are incumbent upon the miners for their own safety.

While discussing this subject, it will not be amiss to mention two other factors that have played important parts in connection with the fatal and serious accidents that have occurred within the past three years, viz., dynamite and fuse—the former being used in conjunction with blasting powder, resulting in almost every instance in an overcharged shot, while the use of fuse in preference to squibs has been the cause of accidents in many ways, such as delayed or premature shots.

The great danger in this practice is the fact that the shot firer will commence lighting shots at the head of an entry and continue from one room to another as long as there are any shots to light in that part of the mine, and the fuse on which the shots are tamped being cut at different lengths, will occasionally result in a dozen or more exploding simultaneously, causing a severe explosion, or an accident from the extra heavy concussion.

Both of the above practices can not be condemned too severely, and there should be laws enacted prohibiting the use of either dynamite or fuse in blasting coal.

Three of the unfortunates that met their death during the year were not mine employes. One, a boy under fourteen years of age (the minimum age prescribed by law at which boys are allowed to work in the mines of this State), had been sent into the mines by his parents to assist an older brother, who had been working with their father. The father was absent on that day. The other two persons were merely visiting the mine in which they met their death.

A history of each of the other fifteen fatalities not commented on above will be found in the description of fatal accidents given below.

## FATAL ACCIDENTS.

### Clay County.

January 5th—Goldy Hadley, miner, was almost instantly killed in the Gifford No. 2 Mine. He was working off some loose coal in a break through, and in doing so, uncovered a bad slip in the roof, when at about 10 o'clock, apparently without warning, a large piece of slate fell, striking him on the head, crushing it so badly that he died in twenty minutes.

January 29th—Charles Smith, miner, aged forty-five years, having a wife and two children, was fatally injured by a fall of slate in the Klondyke Mine. He was at work in his room on the morning of above date, mining off some loose coal, when about 9:30 o'clock, apparently without warning, about four tons of slate gave way from a slip which had been exposed in the roof, falling on him and inflicting injuries from which he died at 3 o'clock of same date. His room was well timbered with the exception of this slip, which had been neglected.

April 15—Dora McCullough, driver, age twenty years, married, was fatally injured by being run over with a mine car in the Cornwell Mine. Evidence obtained at the investigation shows that there was a hill some fifty or sixty yards long with about 8 per cent. grade in favor of the loaded cars on the run on which he was driving, requiring two spraggs on one side and three on the opposite side of a trip of two cars. At the time of the accident his trip was found at the bottom of the hill with one spragg in it, and McCullough was sitting up leaning against the car as if he had been squeezed by the mule. He lived about forty minutes and was not able to talk during that time. He leaves a wife and one child.

July 8th—William Buckholz, miner, age twenty-six years, married, was killed by a premature blast in the Brazil Block Coal Company's No. 1 Mine. He and three other miners were employed driving a pair of entries through a rock fault in the above mine. About 3:30 o'clock of the date above named, they had three shots ready to fire in a break through, two sumpers, one located in each corner of the place and one near the roof in the center. The two sumpers were each charged with five sticks of dynamite, tamped on eighteen inches of fuse. The accident was caused in attempting to fire them.

Buckholz lighted one and turned to light the other, when he sank or fell forward on the one he had just lighted and lay there until it had exploded, killing him instantly. The supposition is that he had an attack of heart failure which caused him to fall. He leaves a wife and three children.

November 19—James McGowan, miner, age sixty-four years, married, was fatally injured by falling slate in the Brazil Block Coal Mine No. 1. He and his son were at work in his room in the afternoon, when, apparently without warning, a large piece of slate, 14x12 feet in width and length, fell on him injuring him so that he died three days later. He leaves a dependent wife.

## Daviess County.

September 28th—Charles Mandabach, miner, age thirty-four years, married, has three children, was killed by falling down the Mandabach coal shaft, located near Washington. Deceased was one of the owners of the mine, and the morning of above

date he was working on the top, dumping coal. There were no gates at the top landing, and in switching an empty car he pushed it into the shaft, himself falling to the bottom, being killed instantly. A compliance with the statute requiring gates at the top of the shaft would have prevented this accident.

## Fountain County.

October 14th—Fred Perry, miner, age twenty-six years, single, was fatally injured in the Rush Mine. At firing time on the evening of above date, deceased was standing in the entry when a very heavy shot was fired in a room some fifty feet distant, the force of which knocked him down striking his head against the rail and fracturing his skull. Death resulted a short time after.

## Greene County.

January 10th—Scott Padgett, age forty-one years, married, was fatally injured by the railroad cars at the Templeton Mine. He was employed to bring the flats down to the tipple at the mine, and about 10:45 o'clock, of above date, he was riding on the front end of a car which was being pulled down to the tipple by a mule. When some distance from the tipple he jumped off the car for the purpose of making the mule travel faster, and in so doing caught his heel in the switch frog, throwing him down across the rail. The car passed over both legs crushing them so badly that amputation was necessary, death resulting a short time after the operation was performed. He leaves a wife and nine children.

March 10th—C. Shuts, miner, age seventeen years, single, was killed by a blast in the Glenburn Mine. He was working in a room with his father at the time, and on the evening of above date the father had gone home, leaving the son to fire the shots, two in number. At about 3:30 p. m. he attempted to fire one of the shots when it exploded prematurely, either from a defective squib, or by his lighting the squib too close to the powder. He lived two days after the accident.

April 28th—Ross Figgins, machine helper, age thirty years, married, was killed by falling coal in the Midland Mine. On the

above date he was at work shoveling slack after a machine. He and his machine runner were making the last cut in the right-hand corner of a room in which a piece of loose coal had been left from the preceding cut. They had the cut nearly finished, when about two and one-half tons of the coal gave way, striking and killing him instantly. He leaves a wife. This accident could have been prevented by a small amount of labor on the part of the loader in working off the loose coal.

July 1st—August Klusmier, miner, age twenty years, married, was instantly killed by falling slate in the Black Creek Mine. This accident was investigated by Mr. Dodds, Assistant Inspector of Mines, who reports that deceased did not have his room properly timbered, as being the prime cause of the accident. He leaves a wife and one child.

August 19th—Edward Culp, driver, age twenty-five years, married, was fatally injured in the Green Valley Mine. On the afternoon of above date, he had gone into an entry after a trip and had instructed another driver to follow him in and pull a car from a room outside of where Culp was going. The driver who followed him in left his empty car stand in the entry while he went into the room after the loaded one. Deceased seemingly had forgotten the instructions he had given the other driver, as he came down the entry at rather a fast rate of speed, standing on the front end of the loaded car, which collided with the empty one, crushing him, inflicting injuries from which he died ten days later. He leaves a wife and one child.

August 27th—Israel Hughes, Jerryman, age thirty years, married, was killed by falling slate in the North West No. 3 Mine. At about 11 o'clock on the above date, he and one other person were at work cleaning up a fall of slate on one of the cross entries when, apparently without warning, a large piece of slate fell on him, killing him instantly. The slate had been examined by himself and the boss in the morning before commencing work, both pronouncing it safe to work under. He leaves a wife.

August 28th—Michael Schafer, miner, age twenty-nine years, single, was fatally burned by a powder explosion in the Antioch Mine. On the afternoon of above date, he had made up his cartridges, and was cleaning a blasting barrel. In order to dry it, he fired a squib through it. The squib, passing through the

barrel, struck the face of the coal and bounded back into the loose cartridges, firing them, they in turn exploding the powder in the keg sitting near by, burning him so badly that he died three days later at St. Anthony's Hospital in Terre Haute.

October 15th—Logan Edington, miner, age seventeen years, single, was killed instantly by falling off an ascending cage in the Letsinger shaft. Little could be learned of this accident, other than the fact that the proper signal had been given. The engineer replied at the top of the shaft with the answering signal, after which deceased got on the cage and it was belled away. When the cage reached the surface he had disappeared. The supposition is that he lost his balance and fell off the cage.

December 4th—George Gilman, miner, age twenty years, was fatally injured by a delayed shot in the Black Creek Mine. Little could be learned of this accident other than the deceased had lighted his shot and retired to an adjoining room for safety, and after waiting a while, it is presumed, thinking the squib had gone out, he started back to try another one, but when within a few feet of the shot it exploded, injuring him so that he died on December 6th, at St. Anthony's Hospital, Terre Haute. He leaves a wife.

December 5th—Joseph Maney, age forty years, miner, married, was killed in the Antioch Mine by a piece of coal thrown from a shot. This accident was investigated by Assistant Inspector Mr. Thomas, and from evidence obtained it was learned that there were four shots fired inside of the room in which deceased was working, one of which was in the face of the entry about eighty to one hundred feet distant. Also that the shots in this mine are tamped on fuse. At about 3:20 o'clock the entry man lighted his shot and ran past deceased's room calling him to come. Deceased then lighted his shot and ran out on the entry. Just as he reached his room parting, the shot in the face of the entry exploded, throwing a piece of coal, which struck deceased just behind the left ear, injuring him fatally. When found by parties who returned to look for him he was lying in an adjoining room in an unconscious condition, from which he did not recover. He leaves a dependent wife and two children.

December 17th—Charles Moore, miner, age twenty-three years, single, was killed by a falling slate in the Victory Mine.

Deceased and two other persons were working at night, shooting down slate, for the purpose of making height at a point on the double parting about seventy feet from the shaft bottom in the above mine. At about 10 o'clock p. m. of the date named they had fired two shots in the slate, one on each side of the entry. The shots did not bring the slate down, but left it in such a condition that it was almost ready to fall. For some reason, deceased went in under it, it is thought to get a couple of cap-pieces to be used as wedges, and while under it a large piece of the slate fell on him, inflicting injuries from which he died at 11 o'clock the following day.

## Knox County.

July 14th—Walter Welty, aged seventeen years, was killed by falling down the Knox Coal Company's shaft located at Bicknel. Deceased was not an employe of this company, but on this evening was visiting the night engineer. Deceased requested the engineer to let him down the shaft, which he refused to do. The engineer then went into the boiler room, to attend to his fires, and when he returned deceased had disappeared. On investigation he was found at the bottom of the shaft, life extinct. The supposition is that he opened the shaft gate to step on the cage, which he thought was at the ground landing. It being very dark, he did not see that the cage was not there and stepped into the open shaft.

December 14th—Claude Alsman, not an employe, age seventeen years, single, was killed by an ascending cage in the Knox Mine. This accident was investigated by Assistant Inspector Mr. Dodds, and from evidence taken at the inquest it was learned that deceased was not an employe of this company, but had gone down into the mine to visit some friends and look around the mine. When coming up out of the shaft with a number of other persons he lost his balance, presumably caused by the motion of the cage, leaned over and was caught by a buntin, and thrown back down the shaft, a distance of about seventy feet. Life was extinct when he was brought to the surface.

## Pike County.

December 19th—Riley Rumble, driver, aged twenty-six years, single, was fatally crushed between a mine car and the entry rib in the Littles Mine. He was standing on the front end of a trip of cars at a double parting. There were four mules standing in the way, and he was waiting for them to move, so that he could start to the shaft bottom with his trip. When his mule started to pull the cars, in leaning over to avoid the other mules, he was caught between the car and the rib and crushed so badly that he died two days later.

## Parke County.

January 7th—Peter August Johnson, miner, aged seventy-six years, single, was killed in the Mary Mine. He was at work loading a car of coal on the morning of above date, working some eight feet back from the face of his room, which was well timbered, when a piece of slate, about 250 pounds weight, fell on his back, driving his face to the floor. The supposition is, that the blow stunned him, and that while in this unconscious condition with the rock laying on his head, holding his face to the floor, he was smothered to death.

June 5th—William Daniels, shot firer, aged thirty-nine years, married, met his death by suffocation in the Briar Hill Mine. Deceased and one other miner were employed to fire the shots in the above mine.

It was developed by the investigation that on the evening of the 5th, they had nearly completed their work and a number of very heavy shots had been fired on the first south entry, this being the point where they were then working. The supposition is, that Daniels lost his way in the mine, owing to the powder smoke. When found he was lying near the face of the entry where the first shots were fired life extinct. He leaves a wife and two children. Overcharged shots were largely responsible for this accident.

July 6th—Jesse Perkins, miner, age fifty-two years, married, was killed by a premature shot in the Zeller-McClellan Columbia No. 1 Mine. He had tamped a shot on a fuse on the evening

## Sullivan County.

March 5th—Walter Kemp, driver, age twenty-two years, single, was killed in the Hymera No. 2 shaft about 11 o'clock on the morning of above day. Kemp, who was driving a mule on the night shift, got on the cage with his mule preparatory to leaving the mine. The cage was belled away in the usual manner, but when it reached the surface the mule was found standing on the cage, but the driver had disappeared. The alarm was given at once and on investigation, Kemp was found in the sump at the bottom of the shaft. No outcry, that would indicate what caused him to fall off the cage, had been heard.

March 14th—George Bemis (not employed), age fourteen years, was fatally injured by a mine car, in the Phoenix No. 5 Mine. On the morning of above day, he had gone into the mine to help his brother, and was assisting him to load a car of coal. There was considerable loose coal thrown on the roadway by a shot some distance back from the face of the room. The room they were working dips with rather a strong grade toward the face. In cleaning up the roadway, they had used a cap-piece to check the car. Deceased was working in front of the car, attempting to remove the chalk from in front of the car wheel for the purpose of letting the car down nearer the face of the room, when it started and caught him against a prop, crushing him, inflicting injuries from which he died within a few hours.

April 2d—Murry Hunt, driver, age twenty-one years, married, was fatally injured by a gas explosion in the Green Hill Mine. On the morning of above day,. Hunt, in company with another laborer and the mine boss, had gone into the mine for the purpose of repairing a dam which had been built to shut off the water in the old workings. The dam had been constructed of three walls of timber, packed between with clay. In order to make the necessary repairs, the greater portion of these timbers had to be torn out.

By 9:30 o'clock a. m. two of the walls had been removed, and the mine boss had picked up a bar and knocked out the wedge over the inner wall and raised his lamp to the opening for the purpose of examining the interior of the dam. Considerable gas

1 Mine. About 11 o'clock a. m. of above date, he was following his driver from his door out to the double parting when a large piece of slate measuring eleven by eight feet, length and breadth, four inches in thickness fell on him, inflicting injuries from which he died ten hours later

February 28th—Charles Wilden, miner, age forty-nine years, married, was fatally injured in the Cox No. 3 Mine, by being struck with pieces of coal thrown from a delayed shot. He had two shots ready to fire at firing time, 3:30 p. m., on the evening of above date, one of which he had lighted and retired to a place of safety. After waiting awhile, he heard a shot explode, which he thought was in his room. Results, however, proved it to be in an adjoining room. Having heard the explosion, he started back into his room to light what he thought was his remaining shot and when within ten or twelve feet of the face, his first shot exploded, pieces of coal from it striking and injuring him to such an extent that he died the evening of the same day. He leaves a wife and eight children. A compliance with the statute, requiring shots to be fired in rotation would have prevented this accident.

March 2d—Julius Currey, miner, single, age eighteen years, was killed by falling slate in the Lucia Mine. Evidence obtained at the investigation shows that at the time of the accident at 7:30 a. m., he was either setting a prop, or sounding the roof, it could not be determined which. He was found under a piece of slate with a sledge hammer in his hands. The section of slate was twenty-one feet long, seven feet wide and about eight inches thick. There were thirty-eight available props in the room at the time of the accident, and had a part of them been set, the accident could have been prevented.

May 15th—Matthew Barr, miner, age thirteen years, was fatally injured by falling slate in the Columbia No. 2 Mine. This was his first day in the mine and he was working with his father driving a break through off of a double parting. They had finished their day's work about 1:30 o'clock p. m., and the boy was back at the mouth of the break through gathering up some picks, when about one hundred pounds of slate fell on him, injuring him so that he died on the following day.

instance, or the accident might have been prevented. The facts that the loose slate was located at a double parting where the drivers and mules during the day frequently were compelled to pass under it, in going to and from their work, and that the noise made by the tramping of the mules, moving mine cars, motors, etc., would drown any noise made by the slate in cutting, chipping, or other indications that it was about to fall, should have impelled double precautions being taken at points of this kind, in the way of timbering or taking the slate down.

October 8th—J. E. Chapple, miner, age nineteen years, single, was fatally burned by the explosion of a keg of powder in the Jackson Hill No. 2 Mine. A keg of powder which belonged to the deceased had been sent down the mine and was left laying on the roadside until it came his turn for a car. Deceased and a fellow miner were playing with the powder, driving nails into the keg, thus causing a spark which ignited the powder and brought about the explosion with the above results.

October 14th—A. L. Gaston, timberman, age thirty-nine years, married, was killed by falling down the Island Company's shaft No. 4. He was at work on the above date, putting a midwall betwen the hoisting and fan shafts. The midwall had been constructed to a depth of about one hundred and thirty feet, and the fan shaft was four by nine feet in size.

Deceased was lowering his brattice lumber shiplap, six inches by sixteen feet, down the fan shaft in a sinking bucket, the bucket being about two feet ten inches across. About 1:15 p. m. of above date, he had loaded the bucket with fifteen pieces of the shiplap, which were set in loose, the top ends dragging down the side of the shaft. He also got into the bucket himself to descend. Although advised by both the mine boss and the engineer not to do so, he persisted in going down with the lumber, and when about one hundred and thirty feet from the surface, which is about half way down, by some means or other he fell out of the bucket, falling to the bottom of the shaft and was instantly killed. He leaves a wife and six children.

December 8th—Adolph Hellman, loader, age forty years, married, was killed by a shot blowing through a pillar in the Hymera No. 1 Mine. He was working in room No. 30 on the second south entry. The room was only partially turned, being driven in

about twenty feet, and is directly opposite a break through which had been driven from the second south to within one foot of being through to inside south entry. This entry had been driven just about to the outside edge of the break through, and the entry man in the first south had drilled a hole in his entry in the rib next to the break through, and judging from the depth of the hole knew that his powder would be bedded somewhere opposite. Also knowing that the pillar was very thin, he warned deceased of the danger of remaining in his room when the shot was fired. About 1:30 o'clock p. m. the entry man lighted his shot and called deceased to come out of his room, he replied all right, but continued at his work until the shot exploded, blowing through the pillar and throwing a large quantity of loose coal into the room neck, striking him and killing him instantly. He leaves a wife and two children.

## VANDERBURGH COUNTY.

The first fatal accident to occur in the mines of Indiana, during the year 1903, was that of Louis Pletcher and Richard Sanders, miners, both of whom were killed by a premature shot in the Sunnyside Mine, at Evansville, about 3 o'clock p. m., January 3d. There was no one present at the time the shot was fired, and as life was extinct in both when they were found, little could be learned as to the exact cause of the accident. On examination of the working place and surroundings, the face of a twelve-foot entry disclosed the fact that there had been two shots prepared, ready to fire, one in each corner of the face, but only one of which had been fired; the squib in the remaining shot showing evidence of having been lighted, as the sulphur on the match was considerably charred. Pletcher and Sanders were working buddies, driving a pair of entries together, and the presumption is that both had gone into the entry where the accident occurred, for the purpose of firing the two shots, each man to light one, and in doing so, the shot which exploded was either lighted too close to the powder, or the squib was defective, and when the shot exploded the concussion extinguished the remaining squib, with the result as above described.

December 2d—Wm. Ray, miner, age fifteen years, was fatally burned by a powder explosion in the Sunnyside Mine. About

10 o'clock a. m. of above date, he was filling a can of powder from a full keg, when his lamp fell into the can, exploding the powder therein as well as the remaining powder in the keg, inflicting burns from which he died during the night following.

## Vermillion County.

May 15th—Thomas Durkin, driver, age thirty-five years, married, was fatally injured by mine cars in the Oak Hill Mine. About 11 o'clock a. m. of above date, deceased had come out to the double parting with a loaded trip. The double parting is located at the foot of a hill some two hundred yards in length; the coal being hauled from this point by rope haulage.

A trip of fifteen cars had just reached the top of this hill, which rises with rather a sharp grade, when in some way they became detached from the rope and ran back down the hill into the empty siding, striking the empties between which deceased was standing, injuring him so that he died on the evening of the same day. He leaves a wife and two children.

July 27th—Joseph E. Balcak, car coupler, age twenty-six years, single, was killed by coming in contact with an electric wire, in the Klondyke Mine. About 1 o'clock of above date he was coupling cars on a siding or double parting which forms the east terminal of the motor haulage in the Klondyke Mine. The trolley wire extends in past the siding a short distance, and stands about thirteen inches above the top of the mine cars and about on a line with the outer edge of the car. Deceased had stooped under the wire, reached in between the cars and made his coupling and when rising touched the wire with his left shoulder. He tried to make an outcry and a trapper boy standing nearby seeing his condition ran to him and tried to pull him away from the wire, receiving a shock which knocked him down. The boy then ran for help, but when it had arrived Balcak was dead.

As soon as notified of the accident the engineer examined his voltmeter and found that it was carrying but two hundred and forty-seven volts, two hundred and fifty being the maximum load carried. It is generally considered by electricians and other persons conversant with electric power that two hundred and fifty volts will not kill a human being, and in fact is not considered

dangerous unless the contact continues for some length of time. In this connection we may say, there is never a day, in the mines somewhere in the State that some person does not come in contact with a live wire carrying two hundred and fifty volts, with no serious results.

In the above case, however, a combination of circumstances brought about the accident. The floor around the double parting was wet, and deceased was sweating and was resting his hands on the car irons, his left side also touching the irons on the car and his left shoulder the live wire, thus forming a direct circuit through his heart, which may possibly have been weak. The evidence proves conclusively that this death at least was due entirely to an electric shock.

July 20th—Harry Titus, miner, age twenty-five years, was fatally burned by a powder explosion in the Indiana Fuel Coal Company's No. 5 Mine. On the evening of above date he was making up his cartridges preparatory to charging his shots and was pouring the powder into the cartridge from a quart can which he had filled from his full keg, sitting near by. A spark fell from his lamp into the can, firing it, and this in turn exploding the powder in the keg, with above results. Had deceased observed the statute governing the distance a lamp shall be set from the powder when cartridges are being made up, this accident would not have occurred. Titus leaves a dependent wife and three children.

September 29th—Benjamin Bishop, shot firer, age thirty-five years, married, met his death from the effects of a windy or blown-out shot in the Indiana Fuel Coal Company's No. 5 Mine. Deceased and one other miner were employed as shot firers in the above mine. On the evening of the date mentioned they had nearly completed their work, each man working in separate parts of the mine. About 8 o'clock p. m. deceased fired a shot in the face of an entry. This shot was drilled three feet past the cutting or loose end, one foot past the cutting or loose end being the maximum distance. The shot was five and one-half feet thick, five feet being the maximum thickness provided by law.

The shot was fired with eight pounds of black powder and caused a smoke explosion. When found deceased was lying in

a room about fifteen feet from the face of the entry, life extinct. He leaves as dependents three children.

## Vigo County.

January 26th—John Crabb, miner, age forty-eight years, married, was killed in the Glen Oak Mine. He was at work in his room loading a car, at 7:30 o'clock on the morning of above date, when about two tons of slate fell on him, killing him instantly.

His room was well timbered to within seven feet of the face, a large water slip lay across the face of the room which had been exposed by shots fired the previous evening, and he either did not notice it, or failed to examine the roof, as this was the direct cause of the accident. Deceased leaves a wife and five children.

January 26th—James Wesmer, miner, married, was suffocated by inhaling the smoke and heated air, caused by the burning of the tipple at the Harris and Lankford Mine. Somewhere between the hours of 8 and 10 o'clock on the morning of above date, Archie Ferguson, one of the top men employed about the mine placed a can of black oil or car grease by the side of the stove in the tipple, for the purpose of melting it, after which he resumed his work incident to the care of the pit top. The grease being set so close to the stove, soon became very hot and ignited, setting fire to the tipple, completely destroying it together with the head frame and fan house. There were nineteen persons and two mules in the mine at the time of the fire.

The driver at the bottom of the shaft was notified as soon as the fire was discovered and he gave the alarm to the men inside the mine, after which he returned to the shaft bottom and was hoisted to the surface on the cage. By this time, however, the fire had gained such headway that the cages could not be used, and there being no manway, or second outlet at this mine, the miners with one exception, Virgil Beck, who climbed the buntins, remained in the mine until the tipple had burned and until arrangements could be made for a rescuing party to enter and assist them. When the rescuing party had reached the men, it found Wesmer and four other persons badly overcome by the smoke and heated air. Wesmer died within a few minutes after being brought to the surface. The other four recovered in a very short

time with no very serious results. Fortunately none of the other miners were injured. Wesmer leaves a wife.

November 26th—Abel H. Pell, miner, age thirty years, married, was killed at the bottom of the J. Ehrlich coal shaft. He was at work on the above date, with the mine boss and a fellow miner, removing the old guides in the shaft preparatory to replacing them with new ones.

From evidence obtained at the investigation, Pell was working about seven feet up from the bottom of the shaft, standing on a buntin. About 8:30 the cage in the compartment in which they were working was ordered to the top of the shaft for the purpose of sending down a new guide timber, and it is supposed that the cage or water box, while descending in the opposite compartment from where deceased was standing, caught his head against a buntin, crushing it and killing him instantly.

## Warrick County.

September 25th—Thomas Robinson, miner, age fifty-five years, was fatally injured by a delayed shot in the John Archibald Coal Company's No. 1 Mine. At firing time, 3.30, on the evening of above date, he was attempting to fire a shot, having lighted the squib and retired to a place of safety. The squib did not fire as quickly as he thought it should and after waiting awhile thinking it had gone out, he went back into his place for the purpose of trying another one. When he had gotten within about eighteen feet of the face, the shot exploded, pieces of coal striking and so injuring him that he died within a few minutes. He leaves a wife and one child dependent.

September 11th—Stigal, miner, age fifty-three years, married, was killed by a premature blast in the Air Line Mine. From evidence obtained at the investigation of this accident it is evident that it was due to one of two causes, viz., a faulty squib, or carelessness in lighting it. An eyewitness who was standing within eighteen feet of deceased when he attempted to fire the shot testifies that the shot exploded almost the instant he touched the squib with his light. He leaves a wife and two children.

September 29th—Henry Shopenhurst, miner, married, was fatally injured by falling slate in the Big Vein No. 3 Mine. At 7:30 a. m. he was at work in his room loading a car of coal, shoveling from in front of the car. Suddenly a large body of coal gave way falling on him and injuring him to such an extent that he died at 11 o'clock a. m. of the same day. He leaves a wife.

A summary of the names of persons, occupation, date and cause of each death, the name of the mine and county in which the fatalities occurred are given in the following table:

# TABLE OF FATAL CASUALTIES.

## CLAY COUNTY.

| Date. | Name. | Age. | Dependents. | Residence. | Occupation. | Cause of Accident. | Mine. | Company. |
|---|---|---|---|---|---|---|---|---|
| January 5. | Goldy Hadley | | | Brazil | Miner | Falling slate | Gifford No. 2 | Collins Coal Co. |
| January 29 | Chas. Smith | 45 | 3 | Staunton | Miner | Falling slate | Klondyke | C. Ehrlich Coal Co. |
| April 15 | Dora McCullough | 20 | 2 | Cardona | Driver | Mine car | Cornwell | Jackson Coal and Mining Co. |
| July 8 | Wm. Buckholz. | 30 | 4 | Brazil | Miner | Premature blast | Brazil B No. 1 | Brazil Block Coal Co. |
| November 18. | Jas. McGowan | 64 | 1 | Knightsville | Miner | Falling slate | Brazil B No. 7 | Brazil Block Coal Co. |

## DAVIESS COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| September 26. | Chas. Mandabach. | 34 | 3 | Washington | Miner | Fell down shaft | Mandabach | Mandabach Bros. |
| June 26 | Mat Ryan | 38 | 4 | Cannelburgh | Driver | Falling slate | Mutual | Mutual Mining Co. |

## FOUNTAIN COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| October 14. | Fred Perry | 26 | .. | Cates | Miner | Windy shot | Rush | Rush Coal Co. |

## GREENE COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| January 10. | Scott Padgett | 41 | 10 | Linton | Laborer | Run over by cars | Templeton | Co. |
| March 10 | | 17 | .... | Linton | Miner | Premature shot | Glenburn | |
| April 28 | | 30 | 1 | Midland | Machine hand | Falling coal | Midland | |
| July 1 | | 30 | 2 | Linton | Miner | Falling slate | Black Creek | |
| August 19. | | 25 | 2 | Jasonville | Driver. | Mine cars | Green Valley | |
| August 27 | | 30 | 1 | Jasonville | Laborer | Falling slate. | Northwest No. 1. | |
| August 28 | Mike Schafer | 29 | . | Antioch | Loader | Powder explosion | Antioch | |
| October | Logan Edington | 18 | | Midland | Miner | Fell off cage | Letsinger | |
| December 4 | Geo. Gilman | 30 | 1 | Linton | Miner | Delayed shot | Black Creek | |
| December 5. | Jos. Maurey | 40 | 3 | Antioch | Miner | Coal from shot | Antioch | |
| December 17. | Chas. Moore | 23 | 1 | Linton | Laborer | Falling slate | Victoria | |

# TABLE OF FATAL CASUALTIES—Continued.

## KNOX COUNTY.

| Date. | Name. | Age. | Dependents. | Residence. | Occupation. | Cause of Accident. | | |
|---|---|---|---|---|---|---|---|---|
| July 14 | Walter Welty | 17 | 1 | Bicknel | Not employed | Fell down shaft | Knox | Knox Coal Co. |
| December 14 | Claude Alsman | 17 | ... | Bicknel | Not employed | Ascending cage | Knox | Knox Coal Co. |

## PIKE COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| December 19 | Riley Rumble | 26 | .. | Littles | Driver | Mine cars | Littles | S. W. Littles Coal Co. |

## PARKE COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| January 7 | P. A Johnson | 76 | | Brazil | Miner | Falling slate | Mary | |
| February 28 | Chas. Wilden | 49 | 9 | Coxville | Miner | Delayed shot | Cox No. 3 | |
| March 2 | Julius Currey | 18 | ... | Mecca | Miner | Falling slate | Lucia | |
| May 15 | Matthew Barr | 13 | | Perth | Miner | Falling slate | Columbia No. 8 | |
| June 15 | Wm Daniels | 39 | 2 | Coxville | Shot firer | Suffocated | Briar Hill | Co. |
| July 6 | Jesse Perkins | 52 | 1 | | Miner | Premature shot | Columbia No. 1 | |
| August 14 | Bass Montgomery | 26 | 5 | Mecca | N fireman | Explosion | Lucia | |
| September 15 | James Rosa | 18 | | | Miner | Suffocated | Columbia No. 2 | |
| October 30 | Thos. Kerrick | 28 | 3 | Coxville | Miner | Falling slate | Briar Hill | Co. |
| November 0 | Albert Snodgrass | 15 | ... | Mecca | Trapper | Falling slate | Mecca No. 1 | Mecca Coal and Mining Co. |

## SULLIVAN COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| March 5 | Walter Kemp | 22 | ... | Hymera | Driver | Fell off cage | Hymera No. 2 | ing Co. |
| March 14 | George Bemis | 13 | .. | Alum Cave | Not employed | Mine car | Phoenix No. 5 | Coke Co. |
| April 2 | Murry Hunt | 21 | 2 | Sullivan | Driver | Gas explosion | Green Hill | |
| May 11 | Ludwig Hoffman | 25 | .. | Star City | Loader | Falling slate | Star City | |
| January 10 | Isaac Prior | 57 | 6 | Shelburn | Timberman | Falling slate | Shelburn | |
| July 3 | Clarence Wharton | 18 | .... | Dugger | Driver | Falling slate | Dugger | Co. |
| October 8 | J. E. Chapple | 19 | ... | Jackson Hill | Miner | Explosion | Jackson Hill No. 2 | Coke Co. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| October 14 ... | A. L. Gaston..... .. | 56 | 7 | Superior ..... | Timberman.... | Fell down shaft ... | Island No. 4 ..... | Island Coal Co. |
| December 18. | Adolph Hellman ..... | 40 | 3 | Hymera .... . | Loader..... | Shot through pillar | Hymera No. 1 . | Hymera Coal Co. |

VANDERBURGH COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| January 3 . | Louis Pletcher ..... | .... | .... | Evansville .... | Miner.. ..... | Premature shot ... | [illegible] | Sunnyside Coal Co. |
| January 3 .. | Richard Sanders ..... | ... | ... | Evansville.... | Miner..... | Premature shot.... | | Sunnyside Coal Co. |
| December 2 . | Wm. Ray ..... | 15 | .... | Evansville..... | Miner ..... . | Powder explosion | | Sunnyside Coal Co. |

VERMILLION COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| May 15..... | Thos. Durkin..... | 35 | 3 | Clinton ..... | Driver ..... | | Oak Hill ..... | Oak Hill Coal Co. |
| July 27 ..... | Jos. Balcak ..... | 26 | .. | Clinton ..... | Car coupler .. . | | Prince ..... .... | Keller Coal Co. |
| July 30 ..... | Harry Titus..... | 25 | 4 | Clinton ..... | Miner... ..... | | Brailettes No. 5.. | Indiana Fuel Co. |
| September 29. | Benjamin Bishop..... | 35 | 3 | Clinton ..... | Shot firer ..... | | Brailettes No. 5.. | Indiana Fuel Co. |

VIGO COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| January 6 . | John Crabb ..... | 48 | 6 | Burnett ..... | Miner..... .. | Falling slate..... | Glen Oak . ... | |
| January 26 | James Wesmer . ..... | . | 1 | W. Terre Haute | Miner ..... | Suffocated ..... | Harris-Lankford | |
| June 2 . | Joseph Selker .... .. | 29 | .. | ..... | Cager .... .... | Descending cage . | Nickel Plate..... | |
| November 20. | Abel H. Pell ..... ... | 30 | 6 | Seeleyville..... | Miner ..... .. | Descending cage . | Ehrlich ..... . | |

WARRICK COUNTY.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| September 11. | Wm. Stigal ..... | 53 | 3 | Chandler..... | Miner..... | Premature shot.... | Air Line ..... | |
| September 25. | Thos. Robinson..... | 55 | 2 | Newburg..... | Miner..... | Delayed shot ..... | Star No. 1..... | Co. |
| September 29. | H. Shoenhurst . .... | .... | 1 | Boonville ..... | Miner..... | Falling coal ..... | Big Vein No. 5... | |

## TABLE.

*Nationality of Persons Killed in Indiana Mines in 1903.*

| | | | |
|---|---|---|---|
| American | 30 | Polish | 1 |
| Irish | 3 | Slav | 1 |
| English | 3 | Hungarian | 2 |
| Negro | 4 | Austrian | 1 |
| German | 8 | | |
| Swede | 1 | Total | 55 |
| Scotch | 1 | | |

## COMPARATIVE TABLE,

*Showing Number of Tons Mined in Each Year, the Number of Persons Employed, and the Number of Tons Produced Per Each Death from January 1, 1879, to January 1, 1904.*

| YEAR. | Tons Produced. | Number of Employes. | Deaths. | Tons Per Death. |
|---|---|---|---|---|
| 1879 | 1,196,490 | 3,459 | ..... | No report |
| 1880 | 1,550,375 | No report | ..... | ..... |
| 1881 | 1,771,536 | 4,567 | 10 | 177,153 |
| 1882 | 1,900,000 | No report | ..... | ..... |
| 1883 | 2,560 000 | 5,403 | 11 | 232,727 |
| 1884 | 2,260,000 | 5,716 | 9 | 228,888 |
| 1885 | 2,375,000 | 6,502 | 7 | 339,285 |
| 1886 | 3,000,000 | 6,406 | 7 | 428,571 |
| 1887 | 3,217.711 | No report | ..... | ..... |
| 1888 | 3,140,979 | 6,685 | 17 | 184,763 |
| 1889 | No report | ..... | ..... | ..... |
| 1890 | 3,791 211 | 6,550 | 5 | 758,242 |
| 1891 | 3,819.600 | 6,975 | 5 | 763.900 |
| 1892 | 4,408.471 | 7,600 | 19 | 232,024 |
| 1893 | 4,358.897 | 7,431 | 22 | 193,586 |
| 1894 | No report | ..... | ..... | ..... |
| 1895 | 4,212,084 | 7,885 | 23 | 182,699 |
| 1896 | 4,068.124 | 7,112 | 28 | 170,290 |
| 1897 | 4,088,100 | 7,984 | 16 | 262.630 |
| 1898 | 5,146,920 | No report | 22 | 233,950 |
| 1899 | 5,864,975 | 7,366 | 15 | 390,997 |
| 1900 | 6,283,063 | 8,858 | 18 | 349,059 |
| 1901 | 7,019,203 | 12,096 | 24 | 292,466 |
| 1902 | 8,763 197 | 13,139 | 24 | 365,133 |
| 1903 | 9,992,563 | 15,128 | 55 | 181,683 |

### SERIOUS ACCIDENTS.

The same conditions, causes, etc., will apply to the serious accidents occuring in 1903 as those shown in the description and comments on the fatal accidents.

An aggregate of one hundred and forty-five (145) serious accidents is shown in the table of causes, sixty-four (64), or nearly forty-four per cent., of which were caused by falling slate. On

investigation, at least 19 per cent. of those were found to have occurred at or near the working faces, and in a number of instances were the result of gross carelessness on the part of those injured by reason of their failure to examine the roof, take down loose slate and lack of sufficient props being set.

Twenty-six, or eighteen per cent., were due to explosives, causing windy shots, premature and delayed shots, overcharged shots, shots blowing through pillars, smoke explosions, etc. Of this number there are but few exceptions where the accident could not have been prevented by a reasonable amount of care on the part of those injured while handling explosives, tamping, charging, placing and firing shots.

Forty, or a fraction over twenty-seven and one-half per cent., of the one hundred and forty-five accidents, were caused by mine cars, and those injured were in most instances drivers. Of this class of accidents little can be said, other than the fact that driving is more hazardous than any other employment in or about a mine.

Three persons were burned, two slightly and one seriously, at the same time by a gas explosion. This accident could have been prevented had the persons injured heeded the advice and warning given them by a fellow workman, who on entering the mine early in the morning discovered that the mine doors used in directing the air current into the entry where the explosion occurred, had been left open during the night, thus cutting off the air from that part of the mine and allowing the gas to accumulate.

The remaining accidents were due to the different kinds of employment incident to the operations of a mine, and were generally not of a very serious nature.

A summary of the names of persons injured, occupation, dates, cause and extent of injury, the name of the mine company and county wherein serious accidents have occurred during the year 1903, are given in the following table:

# TABLE OF SERIOUS ACCIDENTS.

## CLAY COUNTY.

| Date. | Name. | Occupation. | Injury. | Cause. | Mine. | Company. |
|---|---|---|---|---|---|---|
| Jan. 30 | Dominic Delaco | Miner | Back injured | Falling slate | Diamond No. 5 | Brazil Block Coal Co. |
| Feb. 10 | Archer Hagerty | Miner | Back injured | Falling slate | Diamond No. 5 | Brazil Block Coal Co. |
| Feb. 17 | William Patterson | Driver | Foot crushed | Mine car | Cloverland | Cloverland Coal Co. |
| Mch 4 | Fred Hale | Miner | Back injured | Falling slate | Monarch | Co. |
| Mch. 28 | Verner Jones | Miner | Back injured | Falling slate | Monarch | Co. |
| Apr. 13 | William Lucas | Miner | Rib fractured | Falling slate | Crawford No. 3 | |
| Nov. 20 | George Myre | Miner | Foot cut off | Falling slate | Cloverland | |
| ... | James Thompson | Miner | Head bruised | Falling slate | Gifford No. 2 | |
| July 18 | Alex McAnnis | Miner | Breast injured | | Cloverland | |
| July 17 | Nelson Backet | Laborer | Leg broken | Falling slate | Lawrence No. 7 | Zeller-McClellan Coal Co. |
| Aug 22 | Walter King | Miner | Face burned | Premature shot | Crawford No 7 | Crawford Coal Co. |
| Aug 13 | Charles Bowers | Miner | Ankle fractured | Falling slate | Lawrence No. 6 | Zeller-McClellan Coal Co. |

## DAVIESS COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| ..... | Henry May | Miner | Foot crushed | Falling slate | Cabel No. 9 | Cabel & Co. |

## FOUNTAIN COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| ..... | Robert Maurey | Miner | Leg broken | Falling coal | Eureka | Cayuga Press Brick Co. |

## GREENE COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Jan. 2 | B Marks | Miner | Back injured | Falling slate | Midland | |
| Jan. 3 | Ira Watson | Miner | Back injured | Falling slate | Island Valley No. 2 | Co. |
| Jan. 13 | Ed. Shoptaw | Driver | Finger cut off | Mine cars | Summit No. 2 | |
| Jan. 14 | Wm. Cramer | Miner | Face burned | Blown out shot | Vulcan | |
| Jan. 14 | Thomas McCauley | Miner | Face burned | Blown out shot | Vulcan | |
| Jan. 14 | Wm. A. Moore | Miner | Face burned | Blown out shot | Vulcan | |
| Jan. 14 | Harvey Gott | Driver | Finger cut off | Mine cars | Summit No. 2 | |
| Jan. 22 | Oscar Jackson | Miner | Spine dislocated | Falling slate | Island Valley No. 2 | Co. |
| Jan. 29 | Emerson Philips | Driver | Hand crushed | Mine cars | Green Valley | Co. |

| | | | | | | |
|---|---|---|---|---|---|---|
| Dec. 29 | John Kennedy | Miner | | Falling slate | Montgomery No 2 | Davies Coal Co. |
| Feb. 3 | Henry Mattox | Miner | | Falling coal | Island Valley No. 3 | Island Valley Coal Co. |
| Feb. 7 | Chose Jones | Miner | | Twisted into dump | Atlas No. 1 | Johnson Coal Co. |
| Feb 18 | Jessie May | Driver | | Falling slate | Atlas No. 1 | Johnson Coal Co. |
| Feb 24 | Thomas Jones | Driver | | Mine cars | South Linton | South Linton Coal Co. |
| Feb. 25 | Albert Gaddes | Driver | | Mine cars | Black Creek | Black Creek Coal Co. |
| Feb. 26 | John Lidenburg | Miner | | Falling slate | South Linton | |
| | Charles Starks | Miner | | Falling slate | Atlas No. 1 | |
| Mch 9 | Frank Mitchel | Miner | | Caught by door | Midland | |
| Mch. 9 | John Crouse | Driver | | Mine car | Summit No. 2 | |
| Mch 25 | I. Griffith | Miner | | Falling slate | Island Valley No. 2. | |
| Apr. 11 | Joseph Drake | Miner | ed | Powder explosion | Gilmour | Co. |
| Apr. 12 | Thomas Maybury | Driver | d | Mine cars | Lattis Creek No. 1. | |
| Apr. 23 | Frank Reynolds | Driver | | Mine car | Summit No. 2 | |
| Apr. 29 | Edward Brown | Driver | Back injured | Mine car and mule | Island Valley No. 3. | |
| June 6 | George Nixon | Cager | Hips injured | Mine car | Lattis Creek | |
| June 27 | George Ritter | Driver | Leg broken | Mine car | Victoria | |
| July 7 | Eli Turpen | Loader | Badly burned | Premature shot | Atlas No. 1 | |
| July 9 | Lewis Shelly | Laborer | Ankle crushed | Falling slate | Midland | |
| July 21 | Henry Fields | Driver | Back injured | Mine cars | Island Valley No. 3. | |
| May 28 | Sim Adkins | Timberman | Leg broken | Falling coal | Midland | |
| | Van Goin | Driver | Back injured | Mine cars | Green Valley | |
| Aug 13 | R. L. McCoulough | Loader | Jaw bone broken | Shot through pillar | Gilmour | Co. |
| Aug. 31 | Elmer Thompson | Miner | Leg broken | Falling slate | Island Valley No 3 | |
| Sept. 11 | John Cox | Miner | Seriously burned | Powder explosion | Island No. 1 | |
| Sept. 25 | Whit Carico | Miner | Foot crushed | Falling coal | Island Valley No 2. | |
| Sept. 29 | Oscar Welch | Driver | Leg broken | Mine car | Gilmour | Co. |
| Sept. 29 | Elmer Overton | Miner | Ankle dislocated | Falling slate | Gilmour | Co. |
| Oct. 5 | Russel Benjamin | Miner | Badly burned | Smoke explosion | Victoria | |
| Oct. 7 | George Haffley | Trapper | Back injured | Mine car | Summit No. 2 | |
| Oct. 8 | Ned Ruthford | Loader | Leg broken | Falling slate | Summit No 2 | |
| Oct 8 | A. Wilson | Superintendent | Arm crushed | Shaker screen | No West No. 1 | |
| Oct. 22 | James Gregory | Miner | Face burned | Smoke explosion | No West No. 1 | |
| Oct 26 | John Bowdel | Driver | Breast injured | Mine car | South Linton | |
| Nov 5 | Earnest Smith | Driver | | Mine car | South Linton | |
| Nov. 2 | John Bradshaw | Miner | | Falling slate | Black Creek | |
| Dec 11 | Samuel Abraham | Miner | | Falling slate | Letsinger | |
| Dec. 21 | William Briggs | Miner | | Caught by cage | Letsinger | |
| Dec. 30 | Robert Pollock | Driver | Leg fractured | Mine car | Black Creek | |

## GIBSON COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| July 1 | Robert Anderson | Ass't M. Boss | Leg broken | Falling slate | Oswald | Princeton Coal & Mining Co. |
| Aug. 27 | Jack McDonald | Miner | Badly burned | Premature shot | Oswald | Princeton Coal & Mining Co. |
| Aug. 27 | F. A. Baney | Miner | Badly burned | Premature shot | Oswald | Princeton Coal & Mining Co. |

## TABLE OF SERIOUS ACCIDENTS—Continued.

### PARKE COUNTY.

| Date. | Name. | Occupation. | Injury. | | Mine. | Company. |
|---|---|---|---|---|---|---|
| Jan. 5 | George Geaskins | Miner | Back injured | Falling slate | Columbia No. 3 | Co. |
| Jan. 23 | John Doskey | Shot firer | Badly burned | Windy shot | Lyford No. 1 | o. |
| Feb. 19 | F Chuskain | Miner | Arm fractured | Falling slate | Lyford No. 1 | o. |
| Mch. 15 | William Hess | Driver | Leg fractured | Mine car | Minshal | |
| Apr. 9 | Robert Conway | Machine R. | Back injured | Falling slate | Brazil Block No. 13 | |
| Apr 20 | George Doidge | Motorman | Back injured | Motor | Cox No. 3 | |
| May 22 | George Limko | Miner | Back injured | Cage | Superior No. 1 | Co. |
| May 21 | John Saltis | Miner | Leg br ken | Falling slate | Brazil Block No. 11 | |
| June 20 | Anglo Barger | Miner | Face burned | Delayed shot | Mary | |
| July 2 | George Perkins | Miner | Leg broken | Premature shot | Superior No 1 | Co. |
| Aug. 13 | Filbert McBay | Miner | Leg broken | Falling slate | Superior No. 3 | Co. |
| Sept. 15 | H Hannam | Miner | Rib fractured | Mine door-w shot | Cox No. 3 | |
| Oct. 5 | Thomas West | Driver | Hand crushed | Mine car | Minshal | |
| Dec. 11 | F. Perovento | Miner | Leg broken | Falling slate | Briar Hill | o. |
| Aug. 12 | R. Downs | Miner | Back injured | Falling slate | Pan-American | Co. |
| Oct 12 | Wm. Golaska | Trapper boy | Back injured | Falling slate | Brazil No. 12 | Brazil Block Coal Co. |
| Oct. 12 | George Migra | Driver | Leg crushed | Falling slate | Brazil No. 12 | Brazil Block Coal Co. |

### PIKE COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| | W. Laswell | Miner | Leg fractured | Falling slate | Hartwell | l Co. |
| Feb. 27 | W Barrowman | Timberman | Back injured | Falling slate | Ayrshire No 4 | |
| Mar. 13 | Wm Wright | Miner | Skull fractured | Falling slate | Massey | |
| Mar. 27 | Lewis Lynn | Laborer | Leg fractured | Falling slate | Ayrshire No 3 | |
| June 10 | Otto Shade | Miner | Leg fractured | Falling slate | Winslow | Coal Co. |
| July 18 | J. E. Keys | Miner | Injured internally | Falling slate | Carbon | |
| Aug. 29 | Wm Titus | Miner | Back injured | Falling slate | Winslow | Co. |
| Sept 9 | Jas Logan | Miner | Back broken | Falling slate | Ayrshire No. 3 | |
| Sept. 18 | Wm Vanpell | Driver | Back injured | Mine car | Littles | Co. |
| | Whitt Hill | Miner | Leg broken | Mine car | Winslow | Co. |
| Dec. 3 | George Kramer | Miner | Foot crushed | Cog on drum | Winslow | Co. |

## PERRY COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Mar. 26 | Wm Co | Miner | Shoulder crushed | Falling slate | Troy | Bergenroth Bros. |
| Oct. 7 | Chas. Shepard | Miner | Leg broken | Falling slate | Cannelton | American Cannel Coal Co. |

## SULLIVAN COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Jan. 7 | Glover Bean | Driver | Hip dislocated | Crushed by mine car | | |
| Jan. 16 | B. Boles | Loader | Leg broken | Falling slate | | |
| Jan. 19 | George Bridwell | Driver | Leg fractured | Mine car | | |
| Jan. 20 | Albert Merris | Miner | Back injured | Falling coal | | |
| Jan. 20 | B. Hughbanks | Miner | Leg fractured | Falling slate | | |
| Feb. 10 | Edgar Able | Miner | Foot crushed | Falling slate | | |
| Feb. 13 | J. Watson | Miner | Shoulder crushed | Mine car | | |
| Mar. 3 | Perry Davis | Loader | Back injured | Falling slate | | |
| Mar. 7 | Miles Payton | Timberman | Arm fractured | Falling slate | | |
| May 19 | Carl Shepard | Loader | Rib fractured | Falling slate | | |
| May 25 | A Rechmel | Miner | Leg fractured | Falling slate | | |
| May 26 | John Martin | Driver | Rib fractured | | | |
| June 22 | Earl Hogg | Driver | Arm fractured | | | |
| Aug. 1 | Homer Phillips | Loader | | | | |
| Aug. 5 | Joseph Watson | Miner | | | | |
| Aug 14 | Frank Crim | Cager | | | | |
| Sept. 14 | Dave Price | Miner | | | | |
| Sept. 14 | J. C. Lewis | Miner | | | | |
| Sept. 14 | Claud Lafoon | Miner | | | | |
| Oct. 8 | Jas. McGell | Miner | | | | |
| Oct. 24 | John Buck | Miner | | | | |
| Oct. 24 | Thos. Wafer | Miner | | | | |
| Oct. 24 | Milt Ford | Miner | | | | |
| Oct. 24 | George Crabb | Miner | | | | |
| Oct. 24 | Chas. McFee | Miner | | | | |
| Oct. 28 | | Miner | | | | |
| Nov. 6 | | Driver | | | | |
| Dec. 6 | | Miner | | | | |
| Dec. 8 | | Miner | | Overcharged shot | | |
| Dec. 28 | James Proffith | Tracklayer | Arm broken | Mine car | Jackson Hill | |

## VANDERBURGH COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Oct. 27 | Wm. Shaken | Trapper boy | Ankle dislocated | Mine car | Sunnyside | Sunnyside Coal Co. |

## TABLE OF SERIOUS ACCIDENTS—Continued.

### VERMILLION COUNTY.

| Date. | Name. | Occupation. | Injury. | Cause. | Mine. | Company. |
|---|---|---|---|---|---|---|
| Jan. 2 | George Perry | Miner | Leg fractured | Falling slate | Buckeye | McClellan Sons & Co. |
| Jan. 12 | Ed Butts | Car coupler | Hand crushed | Mine cars | Brullettes No 3 | Brullettes Creek Coal Co. |
| Mch. 5 | William Taylor | Driver | Leg fractured | Mine cars | Oak Hill | Oak Hill Coal Co. |
| Mch. 20 | Joseph Bolemy | Miner | Badly burned | Smoke explosion | Buckeye | McClellan Sons' Coal Co. |
| Mch. 20 | Charles Poul | Miner | Badly burned | Smoke explosion | Buckeye | McClellan Sons' Coal Co. |
| Mch. 20 | Gus Watson | Miner | Badly burned | Smoke explosion | Buckeye | McClellan Sons' Coal Co. |
| May 24 | Frank Rhodes | Miner | Shoulder fractured | | Crown Hill | Clinton Coal Co. |

### VIGO COUNTY.

| | | | | | | |
|---|---|---|---|---|---|---|
| Jan. 3 | Wesley Webster | Miner | Leg fractured | Falling slate | Lawton | |
| Jan. 2 | A. Leach | Laborer | Leg fractured | Mine car | Grant No. 2 | g Co. |
| Jan 21 | Arthur Felkins | Miner | Leg fractured | Falling slate | Klondyke | Co. |
| May 11 | Percy Philips | Loader | Back injured | Falling slate | Glen Oak | |
| June 4 | Winfred Starks | Miner | Back injured | Premature blast | Fauvre | |
| July 15 | Eugene Miller | Laborer | Skull fractured | Falling slate | Miami | |
| July 24 | George Taylor | Timberman | Back injured | Falling slate | Seeleyville | |
| Sept. 16 | E. Adams | Miner | Arm broken | Falling coal | Union | |
| Sept. 28 | John V Bogle | Laborer | Leg broken | Falling coal | Rosebud | |
| Oct. 14 | Charles Halskin | Miner | Leg broken | Falling slate | Union | |
| Oct. 14 | Joseph Simpson | Timberman | Back broken | Falling slate | Lawton | |
| Oct. 15 | George Hallis | Driver | Hip crushed | Mine cars | Peerless | |

NOTE.—The above table includes only those who have suffered broken bones, cuts, bruises, burns and such other injuries as we think require special mention.

## ACCIDENTS TO MINING PROPERTY.

The most serious accident of the kind to occur during the year was the burning of the Harris and Lankford Mine.

Somewhere near 9 o'clock on the morning of January 26th, fire broke out in the tipple, igniting from a can of overheated car grease which had been placed near the stove to melt.

The result of this fire was the loss of one human life and two mules, also the total destruction of the tipple, engine-room and other mine buildings, which, including the ropes, cages and tipple equipment would place the financial loss near six thousand dollars.

The engine-room at the Star Mine, owned by the John Archibald Coal Company, in Warrick County, was destroyed by fire in March. The loss other than the building was very small as the hoisting machinery and boiler were left in comparatively good condition. The mine was idle about thirty days, which, of course, added considerably to the loss.

The Cable & Co.'s No. 4 Mine, located at Washington, Daviess County, was flooded with water in March and has not been operated since that time.

The engine and boiler rooms at the L. T. Dickason's Glenburn Mine, Linton, Greene County, were destroyed by fire on July 9th. Fortunately the boiler and hoisting machinery were not so badly damaged that they could not be repaired and hoisting resumed in a short time. The dynamo and other electric appliances were a total loss, which necessitated the mine being operated as a pick mine until they could be replaced with new machinery.

A serious fire occurred on July 14th at the Lawton Mine, resulting in a total loss of all mine buildings, as well as a part of the machinery. The work of rebuilding the tipple and setting the machinery, etc., was not completed until September 10th, at which time hoisting coal was resumed. This is one of the Coal Bluff Mining Company's properties. We did not obtain the estimated loss.

A serious mine fire occurred in the interior of the Crown Hill No. 2 Mine, Vermillion County, in August. The flames rushed up the shaft, completely destroying the curbing, tipple and outside buildings.

The Black Diamond Mine, in Fountain County, located near Silverwood, was flooded with water in September, and has since been abandoned.

# TABLE,

*Showing by Counties the Number of Steam Boilers, Number and kind of Motors, Number of Dynamos and Number of Compressors used at Indiana Mines, also the Number of Mines using Rope Haulage.*

| COUNTY. | Number and Kind of Boilers. | | | | Number and Kind of Motors. | | | Number of Dynamos. | Number of Compressors. | Number Mines Using Rope Haulage. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tabular. | Flued. | Cylinder. | Total. | Third Rail. | Traction. | Total. | | | |
| Clay | 27 | 6 | 30 | 63 | 4 | ..... | 4 | 7 | ..... | ..... |
| Daviess | 4 | ..... | 6 | 10 | 2 | ..... | 2 | 1 | ..... | ..... |
| Fountain | ..... | 2 | 2 | 4 | ..... | ..... | ..... | ..... | ..... | ..... |
| Gibson | ..... | 4 | ..... | 4 | ..... | ..... | ..... | ..... | ..... | ..... |
| Greene | 41 | 6 | 5 | 52 | 1 | 1 | 2 | 15 | 4 | 1 |
| Knox | 5 | ..... | 2 | 7 | ..... | ..... | ..... | ..... | ..... | ..... |
| Parke | 18 | 2 | 32 | 52 | 2 | 1 | 3 | 5 | 2 | ..... |
| Pike | 1 | ..... | ..... | 1 | 1 | ..... | 1 | 1 | ..... | ..... |
| Perry | 10 | 6 | 1 | 17 | ..... | ..... | ..... | ..... | ..... | ..... |
| Sullivan | 54 | 5 | 8 | 67 | 3 | 3 | 5 | 18 | 3 | 1 |
| Vanderburgh | 7 | 13 | ..... | 20 | ..... | ..... | ..... | ..... | ..... | ..... |
| Vermillion | 23 | 5 | 2 | 30 | ..... | 2 | 2 | 2 | ..... | 1 |
| Vigo | 22 | 19 | 21 | 62 | ..... | ..... | ..... | 3 | 1 | ..... |
| Warrick | 8 | 2 | 2 | 12 | ..... | ..... | ..... | 1 | 3 | 1 |
| Total | 220 | 70 | 111 | 401 | 13 | 7 | 20 | 53 | 13 | 4 |

# TABLE,

*Showing by Counties the Names of Mines at Which Box Car Loaders are Used, Also Giving Name and Cost of Loader.*

## CLAY COUNTY.

| Name of Mine. | Name of Loader. | Cost of Loader. |
|---|---|---|
| Brazil Block No. 1 | Autumwa | $2,500 00 |
| Brazil Block No. 7 | Autumwa | 2,500 00 |

## GREENE COUNTY.

| | | |
|---|---|---|
| North West | Autumwa | $2,500 00 |
| Lattis Creek | Autumwa | 2,500 00 |
| Green Valley | Autumwa | 2,500 00 |

## PARKE COUNTY.

| | | |
|---|---|---|
| Brazil Block No. 12 | Autumwa | $2,500 00 |

## PIKE COUNTY.

| | | |
|---|---|---|
| Hartwell | Christy | $2,000 00 |

## SULLIVAN COUNTY.

| | | |
|---|---|---|
| Mammoth Vein | Autumwa | $2,500 00 |
| Wilfred | Autumwa | 2,500 00 |
| Glendora | Autumwa | 2,500 00 |
| Cummins | Autumwa | 2,500 00 |

## VERMILLION COUNTY.

| | | |
|---|---|---|
| Rhodes | Autumwa | $2,500 00 |

**Total number of Loaders, 12. Total cost, $27,500.00.**

# EXAMINATIONS.

Examinations of applicants to qualify as mine bosses, fire bosses and hoisting engineers were held at two different times within the past year with results as shown by the annexed table:

## TABLE.

| PLACE. | DATE. | NUMBER OF APPLICANTS. | | | PASSED. | | |
|---|---|---|---|---|---|---|---|
| | | M. B. | F. B. | H. E. | M. B. | F. B. | H. E. |
| Terre Haute | May 5 | 27 | 5 | 41 | 23 | 1 | 25 |
| Terre Haute | Oct. 1 | 26 | 4 | 29 | 23 | 2 | 18 |
| Total | | 53 | 9 | 70 | 46 | 2 | 43 |

We give herewith the names and addresses of those who qualified and received certificates at the above examinations:

### MINE BOSS EXAMINATION HELD MAY 5TH.

| NAMES. | ADDRESSES. | NAMES. | ADDRESSES. |
|---|---|---|---|
| Thomas Moses | Linton. | Malcolm Reed | Linton. |
| P. H. Roeder | Dugger. | Jos. W. Morrison | Linton. |
| John Wright | Linton. | Chas. P. West | Silverwood. |
| Jas. Vennorman | Coal Bluff. | John G. James | Linton. |
| Thomas Anderson | Linton. | Robert E. Collins | Linton. |
| S. G. Raimy | Jasonville. | Robert Baird | Cotes. |
| William E. Vanlien | Jasonville. | Chas. W. Smith | Clinton. |
| John Gardner | Center Point. | Louis Wantelet | Linton. |
| Frank Norris | Dugger. | John Harrison | Linton. |
| John Harrison | Linton. | Harry Tucker | Burnett. |
| William Briddick | Linton. | Edward Atkinson | Linton. |
| John McLeonhardt | Harmony. | Walter Wright | Coal Bluff. |
| G. W. Purcell | Terre Haute. | | |

### HOISTING ENGINEER EXAMINATION, HELD MAY 5TH.

| | | | |
|---|---|---|---|
| Clip Ellingsworth | Jasonville. | F. G. Hise | Linton. |
| Wm. E. Badders | Linton | Wm. H. Chambers | Winslow. |
| C. S. Bradley | Cass. | George Brown | Fontenet. |
| John Dunbar | Dugger. | Edward Hail | Pleasantville. |
| Wm. E. Hooper | Bicknell. | George Gonterman | Linton. |
| Samuel T. Dickey | Midland. | Wm. T. James | Linton. |
| Perry F. Clark | Bicknell. | Caleb E. Summers | Carlisle. |
| W. K. Marton | Rosedale. | Monroe Osborne | Rosedale. |
| Noah Hardesty | Jasonville. | Chas. D. Wilgus | Linton. |
| O. H. Smith | Bicknell. | L. W. Leachman | Clinton. |
| J. N. Gambill | Midland. | John E. Yetter | Veedersburg. |
| John B. Halstead | Jasonville. | W. C. Courtney | Linton. |
| George Annakin | Crawford. | E. E. Chambers | Linton. |
| John Nolan | Linton. | | |

### FIRE BOSS EXAMINATION, HELD MAY 5TH.

| | |
|---|---|
| W. E. Williams | Waterman. |

MINE BOSS EXAMINATION, HELD OCTOBER 1ST.

| NAMES. | ADDRESSES. | NAMES. | ADDRESSES. |
|---|---|---|---|
| Bert McClanahan | Hymera. | Jos. Mullen | Jasonville. |
| David Hoard | Brazil. | Eli Mott | Linton. |
| Raymond Tanner | Linton. | F. A. Richardson | Brazil. |
| Harry Milbourne | Lyford. | C. J. Lawton, Jr. | Bicknell. |
| Levi Bardsley | Shelburn. | Stephen Brown | Linton. |
| S. T. Harvey | Terre Haute. | S. M. Miller | Shelburn. |
| Terrance Carroll | Linton. | James McGow | Fontanet. |
| John McCloud | Sullivan. | Silas Johnson | Edwards. |
| Silas Risher | Linton. | Mathew Bach | Littles. |
| William Johnson | Jasonville. | John E. Lindsay | Harmony. |
| A. R. Stanley | Sullivan. | Curtis Erwin | Seeleyville. |
| T. I. Hiatt | Dugger. | | |

HOISTING ENGINEER EXAMINATION, HELD OCTOBER 1ST.

| | | | |
|---|---|---|---|
| Thomas M. Cody | Linton. | John N. Miller | Clay City. |
| Moses Watts | Jasonville. | Wm. T. Fowler | Princeton. |
| Joseph E. Butler | Dugger. | M C. Cash | Sullivan. |
| Chas. McDarnel | Sullivan. | O. P. Sears | Clinton. |
| Morlan E. Miller | Worthington. | A. M. Brown | Midland. |
| Van L. Plew | Sullivan. | Fred Medecke | Sullivan. |
| Isaac Davis | Francisco. | Wm. L. Goddard | Seeleyville. |
| W. T. Shewmaker | Terre Haute. | James Hale | Linton. |
| J. R. Pearce | Midland. | Benjamin Bird | Jasonville. |

FIRE BOSS EXAMINATION, HELD OCTOBER 1ST.

| | | | |
|---|---|---|---|
| Harry Milbourn | Lyford. | | |

## SERVICE CERTIFICATES.

Thirty service certificates were granted within the year, as follows: Mine Boss, 22; Fire Boss, 1; Hoisting Engineer, 7. Following will be found the names and addresses of those to whom certificates were issued:

MINE BOSS.

| NAMES. | ADDRESSES. | NAMES. | ADDRESSES. |
|---|---|---|---|
| Newton W. Lane | Shelburn. | Julius Ehrlich | Seeleyville. |
| Thomas Davidson | Shelburn. | John Baird, Sr. | Cardonia. |
| W. E. Cowen | Shelburn. | John T. Sterling | Delcarbo. |
| Samuel Bradburg | Shelburn. | Fred W. Newton. | Boonville. |
| Hugh Waugh | Ehrmindale. | John M. Lowory | Shelburn. |
| John H. Davis | Nyesville. | John Taylor | Shelburn. |
| James Taylor | Shelburn. | John W. Miller | Evansville. |
| William Perry | Coal Creek. | Chas. Craig | Diamond. |
| W. P. Harrison | Rockville. | James M. Scully | Alum Cave. |
| Elza Eller | W. Terre Haute. | John Hill | Brazil. |
| M. D. Stevenson | Carbon. | James A. Nolan | Linton. |

### HOISTING ENGINEER.

| NAMES. | ADDRESSES. | NAMES. | ADDRESSES. |
|---|---|---|---|
| R. S. Taylor..... | Shelburn. | Wm. H. Yeager..... | Shelburn. |
| John M. Cummins..... | Hymera. | Lew Davis..... | Shelburn. |
| William Gray..... | Seeleyville. | James T. Mathews..... | Evansville. |
| H. S. Shee ..... | Terre Haute. | | |

### FIRE BOSS.

| | | | |
|---|---|---|---|
| Mark Headley..... | Shelburn. | | |

## DIRECTORY OF MINES.

Table showing the names and addresses of persons and corporations operating coal mines in each county:

### CLAY COUNTY.

| NAME. | ADDRESS. | MINE. |
|---|---|---|
| Brazil Block Coal Company.. | Brazil..... | Brazil Block No. 1. |
| Brazil Block Coal Company.. | Brazil..... | Brazil Block No. 8. |
| Brazil Block Coal Company.. | Brazil..... | Brazil Block No 11. |
| Brazil Block Coal Company.. | Brazil..... | Diamond No. 3. |
| Brazil Block Coal Company.. | Brazil..... | Diamond No. 5. |
| Brazil Block Coal Company. | Brazil..... | Gart No. 5. |
| Brazil Block Coal Company.. | Brazil..... | Gart No. 10. |
| Brazil Block Coal Company.. | Brazil..... | Gart No. 7. |
| Clay City Coal Co ..... | Clay City..... | Briar Hill. |
| Zeller-McClellan Coal Company ..... | Brazil..... | Cloverland. |
| Zeller-McClellan Coal Company ..... | Brazil..... | Lawrence No. 8. |
| Zeller-McClellan Coal Company ..... | Brazil..... | Lawrence No. 7. |
| Jackson Coal and Mining Company..... | Brazil..... | Cornwall. |
| Crawford Coal Company ..... | Brazil..... | Crawford No. 2. |
| Crawford Coal Company ..... | Brazil..... | Crawford No. 3. |
| Crawford Coal Company ..... | Brazil..... | Crawford No 5. |
| Crawford Coal Company ..... | Brazil..... | Crawford No. 6. |
| Crawford Coal Company ..... | Brazil..... | Crawford No. 7. |
| Eureka Block Coal Company | Terre Haute..... | Eureka No 2. |
| Eureka Block Coal Company | Terre Haute..... | Eureka No. 3. |
| C. Ehrlich Coal Company.... | Turner..... | Fortner. |
| C. Ehrlich Coal Company.... | Turner..... | Klondyke. |
| Collins Coal Company..... | Brazil..... | Gifford No. 1. |
| Collins Coal Company..... | Brazil..... | Gifford No. 2. |
| Coal Bluff Mining Company.. | Terre Haute..... | Pratt. |
| Coal Bluff Mining Company.. | Terre Haute..... | Glen. |
| Continental Coal and Mining Company ..... | Brazil..... | Continental. |
| Crawford Coal Company ..... | Brazil..... | Rebstock. |
| Indiana Bituminous Coal Company ..... | Terre Haute ..... | Fairview. |
| Lewis Coal and Mining Company ..... | Lewis ..... | Lewis. |
| Zeller-McClellan Coal Company ..... | Brazil..... | Cloverland No. 2. |

## DAVIESS COUNTY.

| Name. | Address. | Mine. |
|---|---|---|
| Cabel & Company | Washington | Cabel No. 4. |
| Cabel & Company | Washington | Cabel No. 9 |
| Raglesville Coal Company | Raglesville | Hoosier No. 4. |
| Daviess County Coal Company | Montgomery | Montgomery No. 2. |
| Daviess County Coal Company | Montgomery | Montgomery No. 3. |
| Mutual Mining Company | Cannelburg | Mutual. |
| Mandabach Bros. Coal Company | Washington | Mandabach. |
| Wheatland Coal Company | Washington | Wheatland. |

## FOUNTAIN COUNTY.

| | | |
|---|---|---|
| Rush Coal Company | Cates | Rush. |
| Silverwood Coal Company | Silverwood | Silverwood. |

## GREENE COUNTY.

| | | |
|---|---|---|
| Black Creek Coal and Mining Company | Linton | Black Creek. |
| Island Coal Company | Linton | Island City No. 1. |
| Island Coal Company | Linton | Island City No. 2. |
| Island Coal Company | Linton | Island No. 3. |
| Indiana Southern Coal Company | Chicago, Ill | Gilmour. |
| Hoosier Coal Company | Bloomfield | Hoosier No. 1. |
| Island Valley Coal Company. | Linton | Island Valley No. 2. |
| Island Valley Coal Company. | Linton | Island Valley No. 3. |
| Midland Coal Company | Midland | Midland. |
| South Linton Coal and Mining Company | Linton | South Linton. |
| Vulcan Coal Company | Indianapolis | Vulcan No. 1. |
| Summit Coal Company | Chicago, Ill | Summit No. 2. |
| Western Indiana Coal Company | Terre Haute | Templeton. |
| L. T. Dickason Coal Company | Chicago, Ill | Victoria. |
| L. T. Dickason Coal Company | Chicago, Ill | Glenburn. |
| Tower Hill Coal Company | Bloomington | Tower Hill. |
| Green Valley Coal Company. | Linton | Green Valley. |
| Lattas Creek Coal Company. | Terre Haute | Lattas Creek No. 1. |
| Johnson Coal and Mining Company | Columbus, Ohio | Atlas. |
| Antioch Coal Company | Chicago, Ill | Antioch. |
| Fry Coal Company | Terre Haute | Fry. |
| Hoosier Coal Company | Linton | Hoosier No. 2. |
| Letsinger Coal Company | Bloomfield | Letsinger. |
| Northwestern Coal Company | Jasonville | Northwest. |
| Coal Bluff Mining Company. | Terre Haute | Twin. |
| Island Coal Company | Linton | Island No. 5. |
| Johnson Coal and Mining Company | Columbus, Ohio | Atlas No. 2. |

## KNOX COUNTY.

| | | |
|---|---|---|
| Bicknell Coal Company | Bicknell | Bicknell. |
| Vulcan Coal Company | Indianapolis | Edwardsport. |
| Lynn Coal Company | Bicknell | Lynn. |
| Knox Coal Company | Bicknell | Knox. |
| Prospect Hill Coal Company. | Vincennes | Prospect Hill. |
| Enterprise Coal Company | Bicknell | Enterprise. |

## PARKE COUNTY.

| NAME. | ADDRESS. | MINE. |
|---|---|---|
| Brazil Block Coal Company | Brazil | Brazil Block No. 12. |
| Brazil Block Coal Company | Brazil | Cox No. 3. |
| Brazil Block Coal Company | Brazil | Brazil Block No. 9. |
| Rock Run Coal Company | Montezuma | Lucia. |
| Rock Run Coal Company | Montezuma | Mecca No. 1. |
| Wabash Valley Coal Company | Chicago, Ill | Lyford No. 1. |
| Otter Creek Coal Company | Brazil | Mary. |
| I. W. McIntosh Coal Company | Brazil | McIntosh No. 3. |
| New Century Coal and Mining Company | Montezuma | New Century. |
| Zeller, McClellan & Company | Brazil | Superior No. 1. |
| Zeller, McClellan & Company | Brazil | Superior No 2. |
| Zeller, McClellan & Company | Brazil | Superior No. 3. |
| Minshal Vein Coal Company. | Terre Haute | Minshal No. 1. |
| Plymouth Block Coal Company | Carbon | Pan-American. |
| C. B. Harrison | Rockville | Harrison. |
| W. P. Harrison | Rockville | Harrison. |
| Raccoon Valley Coal and Mining Company | Terre Haute | Raccoon. |
| Parke County Coal Company | Rosedale | Parke No. 11. |
| Minshal Vein Coal and Mining Company | Terre Haute | Minshal No. 2. |

## PERRY COUNTY.

| | | |
|---|---|---|
| Bergenroth Bros | Troy | Troy. |

## PIKE COUNTY.

| | | |
|---|---|---|
| Aberdeen Coal Company | Littles | Aberdeen. |
| D. Ingle Coal Company | Ayrshire | Ayrshire No. 3. |
| D. Ingle Coal Company | Ayrshire | Ayrshire No. 4. |
| D. Ingle Coal Company | Ayrshire | Ayrshire No. 5. |
| D. Ingle Coal Company | Ayrshire | Ayrshire No. 6. |
| S. W. Little Coal Company | Evansville | Blackburn. |
| S. W. Little Coal Company | Evansville | Littles. |
| S. W. Little Coal Company | Evansville | Rogers. |
| S. H. Wulfman Coal Company | Huntingburg | Hartwell. |
| J. Wolley Coal Company | Evansville | Petersburg. |
| Aberdeen Coal Company | Littles | Carbon. |
| Massey Coal Company | Oakland City | Massey. |
| Winslow Gas Coal Company. | Winslow | Winslow. |

## SULLIVAN COUNTY.

| | | |
|---|---|---|
| Washington Fuel Company | Chicago, Ill | Bunker Hill. |
| Rainbow Coal and Mining Company | Chicago, Ill | Caledonia. |
| Indiana Chicago Coal Company | Chicago, Ill | Dugger. |
| Green Hill Coal and Mining Company | Sullivan | Green Hill. |
| Hymera Coal and Mining Company | Chicago, Ill | Hymera No. 1. |
| Hymera Coal and Mining Company | Chicago, Ill | Hymera No. 2. |
| West Linton Coal and Mining Company | Linton | Ingleside. |
| New Pittsburg Coal and Min-Company | Chicago, Ill | Phoenix Nos. 1, 2, 3. |
| Keystone Coal Company | Shelburn | Shelburn. |
| Harder-Hafer Coal Company | Chicago, Ill | Star City. |

SULLIVAN COUNTY—Continued.

| NAME. | ADDRESS. | MINE. |
|---|---|---|
| White Ash Coal Company.... | Terre Haute..... | White Ash. |
| Sullivan Coal Company..... | Dugger..... | Freeman. |
| Sun Flower Coal Company... | Dugger..... | Sun Flower. |
| W. S. Bogle Coal and Mining Company..... | Chicago, Ill..... | Glendora. |
| Wilfred Coal Company..... | Shelburn..... | Wilfred. |
| Island Coal Company..... | Linton..... | Island No. 4. |
| Mammoth Vein Coal Company..... | Shelburn..... | Mammoth. |
| Little Giant Coal Company.. | Linton..... | Little Giant. |
| Cummins Coal Company..... | Chicago, Ill..... | Cummins. |
| Indiana Hocking Coal Company..... | Farmersburg ..... | La Blanz. |
| Citizens Coal Company..... | Sullivan ..... | Citizens. |
| J. Wolley Coal Company ..... | Evansville..... | Mildred. |
| Bruillettes Coal Company.... | Terre Haute ..... ... | Bruillettes Creek No. 6. |

VANDERBURGH COUNTY.

| | | |
|---|---|---|
| Diamond Coal Company ..... | Evansville..... | Diamond. |
| H. A. Lozier Coal Company.. | Evansville..... | First Avenue. |
| John Ingle Coal Company.... | Evansville..... | Ingle. |
| Crescent Coal Company..... | Evansville..... | Unity. |
| Evansville Coal and Mining Company ..... | Evansville..... | Union. |

VERMILLION COUNTY.

| | | |
|---|---|---|
| Bruillettes Creek Coal Company ..... ..... | Clinton..... .. | Bruillettes Nos. 3, 5. |
| McClellan's Sons & Company | Clinton..... | Buckeye. |
| Cayuga Press Brick Company | Cayuga ..... | Cayuga. |
| Clinton Coal Company. .... | Clinton..... | Crown Hill. |
| Oak Hill Coal Mining Company ..... | Clinton..... | Oak Hill. |
| Keller Coal Company ..... | Chicago, Ill.. ..... | Prince. |
| Willow Grove Coal Company | Clinton..... | Willow Grove. |
| Brazil Block Coal Company.. | Brazil ..... | Rhodes. |
| Clinton Coal Company..... | Clinton..... | Crown Hill No. 2. |

VIGO COUNTY.

| | | |
|---|---|---|
| Terre Haute Brick and Pipe Company..... | Terre Haute..... | Brick Works. |
| Big Vein Coal and Mining Company ..... | Chicago, Ill..... | Chicago No. 6. |
| Coal Bluff Mining Company. | Terre Haute ..... | Diamond. |
| Coal Bluff Mining Company. | Terre Haute..... | Peerless. |
| Coal Bluff Mining Company. | Terre Haute..... | Lawton. |
| Coal Bluff Mining Company. | Terre Haute..... | Union. |
| J. Ehrlich Coal Company.... | Seeleyville..... | Ehrlich. |
| Grant Coal Company..... | Grant ..... | Grant No. 2. |
| Glen Oak Coal and Mining Company..... | Chicago, Ill... ..... | Glen Oak. |
| Loughner Coal Company..... | Seeleyville..... | Hector. |
| Bruillettes Creek Coal Company .... ... ..... | Clinton ..... | Klondyke. |
| Miami Coal Company..... | Brazil ..... | Miami. |
| Brazil Mining Company..... | Chicago, Ill..... | Nickelplate. |
| Parke County Coal Company | Rosedale..... | Parke No. 10. |
| Vigo Coal Company..... | Seeleyville..... | Ray. |
| Fauvre Coal Company..... | Indianapolis..... | Vigo. |
| Seeleyville Coal and Mining Company ..... .... | Seeleyville..... | Rosebud No. 2. |
| Seeleyville Coal and Mining Company ..... | Seeleyville..... | Royal No. 1. |

VIGO COUNTY—Continued.

| NAME. | ADDRESS. | MINE. |
|---|---|---|
| Harris-Landford Coal and Mining Company | W. Terre Haute | Larimer. |
| Home Coal Company | W. Terre Haute | Eagle. |
| Home Coal Company | Terre Haute | Broadhurst. |
| Fauvre Coal Company | Indianapolis | Redbird. |
| Miami Coal Company | Brazil | Miami No. 2. |
| Deep Vein Coal Company | Terre Haute | Deep Vein. |
| Greenfield Mining Company. | Terre Haute | Greenfield. |
| Sugar Creek Coal Company. | Terre Haute | Sugar Creek. |
| Lost Creek Coal Company | Terre Haute | Lost Creek. |

WARRICK COUNTY.

| | | |
|---|---|---|
| Hall & Marsh | Evansville | Air Line. |
| Big Four Coal Company | Boonville | Big Four. |
| J. Wolley Coal Company | Evansville | Big Vein No. 1. |
| Caledonia Coal and Mining Company | Boonville | Caledonia. |
| J. A. Bryan | Evansville. | Chandlier. |
| Charles Menden | Evansville | DeForrest. |
| John Archibald Coal Company | Evansville | Star No. 1. |
| T. D. Scales Coal Company | Boonville | Electric. |

Names and addresses of mine bosses of the various Indiana mines:

CLAY COUNTY.

| NAMES. | ADDRESSES. | MINES. |
|---|---|---|
| John Bolin | Brazil | Brazil Block Coal Company No. 1. |
| James Burt | Brazil | Brazil Block Coal Company No. 8. |
| Joseph C. Winn | Brazil | Diamond No. 5. |
| Samuel Holden | Brazil | Continental. |
| A. P. Gilmour | Knightsville | Gart No. 7. |
| William Rosser | Diamond | Gart No. 10. |
| John Jenkins | Brazil | Rebstock. |
| Fred Ebermine | Knightsville | Cloverland. |
| Wm. Myers | Turner | Fairview. |
| Fred George | Harmony | Lawrence No. 6. |
| Thomas Thompson | Hoosierville | Lawrence No. 7. |
| Moses Marks | Cardonia | Cornwall. |
| Walter Knox | Asherville | Crawford No. 2. |
| Griff Howell | Centerpoint | Crawford No. 5. |
| William Spears | Brazil | Crawford No. 6. |
| Samuel Lindsay | Hoosierville | Crawford No. 7. |
| John T. Summers | Carbon | Eureka No. 3. |
| H. B. Ehrlich | Turner | Fortner. |
| Jacob C. Ehrlich | Staunton | Klondyke. |
| James Drumm | Brazil | Gifford No. 1. |
| John Barker | Brazil | Glen. |
| James A. King | Brazil | Monarch. |
| M. D. West | Cloverland | Cloverland. |
| Alexander Ferguson | Coal Mont | Lewis. |
| George Myers | Brazil | Cloverdale No. 2. |

DAVIESS COUNTY.

| | | |
|---|---|---|
| A. Kocher | Washington | Cabel No. 9. |
| Arnold Brown | Montgomery | Montgomery No. 2. |
| Edward Dant | Montgomery | Montgomery No. 3. |
| Daniel Davis | Connelburg | Mutual. |
| W. A. Jacobs | Raglesville | Union. |
| Jacob Mandabach | Washington | Mandabach. |
| Frank Harris | Washington | Wheatland. |

## FOUNTAIN COUNTY.

| Name. | Address. | Mine. |
|---|---|---|
| Wm. Perry | Silverwood | Rush. |

## GIBSON COUNTY.

| | | |
|---|---|---|
| George Archibald | Princeton | Oswald. |

## GREENE COUNTY.

| | | |
|---|---|---|
| Reuben Small | Linton | Black Creek. |
| Richard Potts | Linton | Island No. 1. |
| Silas Richer | Linton | Island No. 2. |
| T. Roberts | Linton | Island No. 3. |
| James M. Scully | Gilmour | Gilmour. |
| Frank Lockhart | Linton | Hoosier No. 1. |
| George Epperson | Linton | Island Valley No. 2. |
| Joseph Fennel | Linton | Island Valley No. 3. |
| W. T. James | Linton | South Linton. |
| John Jennings | Jasonville | Midland. |
| Joseph Gibson | Linton | Vulcan. |
| Wm. McQuade | Linton | Summit No. 2. |
| James Burke | Linton | Templeton. |
| Woody Badders | Linton | Victoria. |
| John Kelly | Linton | Glenburn. |
| Joseph Stevenson | Linton | Antioch. |
| Thomas Thomas | Midland | Tower Hill. |
| Isaac Valentine | Jasonville | Green Valley. |
| Thomas Hiatt | Jasonville | Lattas Creek No. 1. |
| James Baxter | Linton | Atlas No. 1. |
| Wm. Vanhorn | Jasonville | Fry |
| Dan Davis | Jasonville | Letsinger. |
| John Quigley | Linton | Twin. |
| Charles Vaughn | Linton | Island No. 5 |
| W. McChalp | Linton | Atlas No. 2. |

## KNOX COUNTY.

| | | |
|---|---|---|
| R. M. Freeman | Bicknell | Bicknell. |
| William Lynn | Bicknell | Knox. |
| Ellis G. Hooper | Bicknell | Lynn. |
| Phelix Mullin | Bicknell | Prospect Hill. |

## PARKE COUNTY.

| | | |
|---|---|---|
| C. B. Harrison | Rockville | Harrison. |
| W. P. Harrison | Rockville | Harrison. |
| Chas. C. Dodge | Knightsville | Brazil Block No. 12. |
| George H. Dodge | Coxville | Cox No. 3. |
| James Lamb | Montezuma | Lucia. |
| Morgan Roberts | Mecca | Mecca No 1. |
| Edward Allias | Montezuma | New Century. |
| Wm. Vanlieu | Lyford | Lyford No. 1. |
| John Chesterfield | Brazil | Mary. |
| John Suttie | Brazil | McIntosh No. 3. |
| George Myers | Brazil | Superior No. 1. |
| Nap Harris | Brazil | Superior No. 2. |
| Jos. Donahey | Brazil | Superior No. 3. |
| Silas Jones | Jessup | Minshal No. 1. |
| Thomas Dalton | Carbon | Pan-American. |
| James M. Coakley | Diamond | Brazil Block No. 9. |
| Thomas Karrack | Coxville | Raccoon. |
| George Mitch | Rosedale | Parke No. 11. |

## PERRY COUNTY.

| Name. | Address. | Mine. |
|---|---|---|
| Wm. Schmuck | Troy | Troy. |

## PIKE COUNTY.

| | | |
|---|---|---|
| H. L. Williams | Oakland City | Massey. |
| John Jones | Ayrshire | Aberdeen. |
| Bart Stinson | Ayrshire | Ayrshire No. 3. |
| W. L. Smith | Ayrshire | Ayrshire No. 4. |
| J. Johnson | Ayrshire | Ayrshire No. 5. |
| D. Ingle, Jr | Ayrshire | Ayrshire No. 6. |
| John Wiley | Petersburg | Blackburn. |
| George Briggs | Hartwell | Hartwell. |
| Herman Rosa | Littles | Littles. |
| H. T. Brewis | Petersburg | Petersburg. |
| John D. Johnson | Ayrshire | Carbon. |
| John Jennings | Winslow | Winslow. |

## SULLIVAN COUNTY.

| | | |
|---|---|---|
| Martin Navin | Farnsworth | Bunkerhill. |
| James Stewart | Farnsworth | Calladonia. |
| Chas. Horton | Dugger | Dugger. |
| Wm. Epperson | Sullivan | Green Hill. |
| John Evans | Hymera | Hymera No. 1. |
| John Griffith | Dugger | West Linton. |
| George Sargant | Jackson Hill | Jackson Hill No. 2. |
| Asa Roberts | Alum Cave | Phoenix No. 1. |
| Alex Fauld | Alum Cave | Phoenix No. 3. |
| C. C. Hall | Shelburn | Shelburn. |
| H. D. Wooley | Delcarbo | Star City. |
| Wm. Green | Hymera | White Ash. |
| O. H. Hendrickson | Dugger | Freeman. |
| Thomas Leighman | Dugger | Sun Flower. |
| Walter Philips | Sullivan | Glendora. |
| Theodore Thompson | Hymera | Hymera No. 2. |
| Ed. Newport | Shelburn | Wilfred No. 1. |
| David Love | Dugger | Island No. 4. |
| John Crosby | Pleasantville | Little Giant. |
| John Patton | Cummins | Cummins. |
| John D. Price | Farmersburg | LaBlanz. |
| Richard Jones | Sullivan | Citizens. |
| John McCloud | Sullivan | Mildred. |

## VANDERBURGH COUNTY.

| | | |
|---|---|---|
| S. T. Harvey | Clinton | Bruillettes No. 3. |
| Wm. Chesterfield | Clinton | Buckeye. |
| R. M. Irwin | Cayuga | Eureka. |
| Wm. F. Brown | Clinton | Crown Hill. |
| Wm. Hutchison | Clinton | Oak Hill. |
| Frank Christy | Clinton | Prince |
| James Boskell | Clinton | Willow Grove. |
| Samuel Ogden | Atherton | Atherton. |

## VIGO COUNTY.

| NAME. | ADDRESS. | MINE. |
|---|---|---|
| Samuel Holden | Coal Bluff | Chicago No. 6. |
| Richard Jackson | Burnett | Diamond. |
| Charles Long | Coal Bluff | Peerless. |
| John Cain | Coal Bluff | Lawton. |
| James Johnson | Fontanet | Union. |
| J. L. Devonald | Burnett | Grant No. 2. |
| Samuel C. Watts | Burnett | Glen Oak. |
| Thomas Maxwell | Seeleyville | Hecktor. |
| William Scank | Burnett | Klondyke. |
| John Baird | Brazil | Miami. |
| Thomas Bingham | Heckland | Parke No. 10. |
| R. T. Bieler | West Terre Haute | Redbird. |
| J. D. Lewis | Seeleyville | Rosebud. |
| John Scott | Seeleyville | Royal No. 1. |
| John F. Irwin | West Terre Haute | Larimer. |
| W. N. Broadhurst | West Terre Haute | Broadhurst. |
| William Winn | Ehrmindale | Miami No. 2. |
| Richard Morgan | West Terre Haute | Deep Vein. |
| James A. Erwin | West Terre Haute | Greenfield. |

## WARRICK COUNTY.

| | | |
|---|---|---|
| T. B. Hall | Chandler | Air Line. |
| John E. Kelley | Boonville | Big Four. |
| P. F. Hargrove | Boonville | Big Vein No. 3. |
| L. M. Gaisser | Boonville | Caledonia. |
| John McCain | Chandler | Chandler. |
| Mark Wilson | DeForrest | DeForrest. |
| Edwin Archibald | Newburg | Star No. 1. |
| William Mason | Boonville | Electric. |

## IN THE FOLLOWING SUMMARY WILL BE FOUND MOST OF THE IMPORTANT TOTALS FOR THE STATE FOR THE YEAR.

## SUMMARY 1903.

| | |
|---|---|
| Number of counties having shipping mines | 14 |
| Number of mines working more than ten men | 184 |
| Number of new mines | 37 |
| Number of mines abandoned | 11 |
| Number of pick miners employed | 7,808 |
| Number of machine, runners and helpers | 588 |
| Number of loaders | 2,232 |
| Number of inside day and monthly men employed | 2,981 |
| Number of outside day and monthly men employed | 1,519 |
| Total number of all employes | 15,128 |
| Number of days worked | 29,928 |
| Number mules used | 1,300 |
| Number kegs of powder used | 327,820 |
| Amount of wages paid to miners | $6,017,021 20 |
| Amount of wages paid to inside day and monthly men | 2,085,116 28 |
| Amount of wages paid to outside day and monthly men | 1,047,434 64 |

| | |
|---|---|
| Total amount of wages paid to all employes | $9,149,572 12 |
| Amount of money spent on improvements | 168,071 96 |
| Total tons machine mine block coal | 187,430 |
| Total tons hand mine block coal | 838,510 |
| Total tons block coal | 1,025,940 |
| Total tons bituminous hand mine coal | 5,749,965 |
| Total tons bituminous hand mine coal | 3,216,648 |
| Total tons bituminous machine mine coal | 8,966,613 |
| Total tons hand mine coal | 6,588,475 |
| Total tons machine mine coal | 3,404,078 |
| Total tons of coal produced | 9,992,553 |
| Total tons of coal consumed in Indiana | 5,009,081 |
| Total tons of coal shipped outside of Indiana | 4,983,472 |
| Total number of steam boilers | 401 |
| Total number of electric motors | 20 |
| Total number of dynamos | 53 |
| Total compressors | 13 |
| Number of compressed air punching machines | 82 |
| Number of electric chain machines | 235 |
| Total number of mining machines | 317 |
| Total number of box car loaders | 12 |
| Total number of fatalities | 55 |
| Total number of serious accidents | 145 |
| Total number of minor accidents | 77 |
| Total number of accidents | 277 |

# ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

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OFFICE OF STATE NATURAL GAS SUPERVISOR,
MARION, IND., January 11, 1904.

*Prof. W. S. Blatchley, State Geologist:*

Sir—I submit to you herewith my First Annual Report, the same being the twelfth annual report from this office. I began the duties of the office March 16, 1903, which is the time in the year when the field is demanding most attention. Since that time, for reasons fully explained in the body of the report, it has not been possible for me to give much time to either collecting material for a report or compiling it. I have given briefly the transactions of the office for the past year and such data regarding the condition of the field as should be interesting to those interested in the natural gas industry.

Permit me to thank you at this time for the very cordial support that I have received from you at all times.

I respectfully submit this report.

Yours sincerely,

BRYCE A. KINNEY,
State Natural Gas Supervisor.

# ANNUAL REPORT OF THE STATE NATURAL GAS SUPERVISOR.

In 1891, a little more than four years after natural gas was discovered in this part of Indiana, a law was enacted by the Legislature then in session, creating the office of State Natural Gas Supervisor and defining his duties. As will be noticed below, these are certainly numerous enough to satisfy the most industrious. Of course, the law should not be criticised, because it does not conform to the conditions at present, for when it was enacted the general conditions in the field were not only very different, but the public idea regarding the generation, storage and life of natural gas has suffered a radical change. Former reports from this office have noted the exact conditions in the field from year to year and the changes, and these will not receive more than passing notice here.

Under the law it is the duty of the State Natural Gas Supervisor to make a personal inspection of all the gas wells of the State so far as it is practical and to see that every precaution is taken to insure the health and safety of workmen engaged in opening gas wells and laying mains and pipes, and of those who, in any manner, use natural gas for mechanical, manufacturing, domestic or other purposes. Here have been given probably one-fifth of the duties assigned to the Supervisor, and with the aid of the one assistant allowed him and by working every week in the year he could doubtless do this work. I inspect all the wells possible while attending to more important duties, at least enough in the various sections of the field to give me a correct idea of the condition of the gas supply. As to the looking after the safety of workmen engaged in the gas industry, I have given it no time, because there is no use of it at this time. Contractors, gas companies and manufacturers employ the most skillful workmen possible, men who thoroughly understand the dangers attending

the handling of natural gas. These are the conditions now. Doubtless they were different early in the history of the field.

In addition to the above it is the duty of the Natural Gas Supervisor to collect and tabulate in his annual report to the State Geologist the following facts: The number of gas wells in the State, with their location and a record of the geological strata passed through in drilling them; the depth at which salt water is reached in the various wells and the height to which it rises; the volume of gas produced by each well so far as it can be ascertained, and also the rock pressure of the various wells; the increase or decrease in the rock pressure and volume of flow of the various wells of the State; the number of miles of mains laid for the transportation of natural gas and the capacity and cost of the same; the amount of capital invested in the gas industry and the number of persons employed in the same; the cost of natural gas for fuel in the various cities and towns in the gas belt, and in addition, a large amount of data regarding the manufacturing industry in the gas field that alone would require the time of one man to collect and tabulate. Much of the information required above is collected and published by the Bureau of Statistics. Nor is this all; according to law it is the duty of this office to inspect all the pipe-lines in the State once each year or as often as the State Geologist may direct. This is a work that is necessary in part only. Most of the larger gas companies look after their lines very carefully. They have no gas to waste. Men are employed to go over the lines at regular intervals. It is a waste of time for the Supervisor to inspect these lines. Of course, as would be expected, there are a number of gas companies that pay but little attention to their field lines and these should have the attention of the Supervisor frequently.

In addition to the numerous duties enumerated above, the Natural Gas Supervisor must see that all the laws of the State pertaining to the drilling of wells and the piping and consumption of natural gas are enforced. This is the most important duty charged to this office at this time. During the early history of the field, the public in general was opposed to the enforcement of the laws that had been enacted to husband the gas. As has been stated many times in the reports from this office, the majority of the consumers of gas, both in the field and in the pipe line cities,

thought, and honestly too, that the supply of gas would last forever, and that no just reason could be given for laws to prevent waste. The conditions have forced a change in public opinion. Questions regarding the generation, storage and pressure of natural gas are given but little attention now. It is admitted everywhere that the supply in this field is about exhausted. What are the most effective measures to adopt to save what is left that it may be utilized as its value warrants? To the minds of most people in the gas field, the only duty of the Natural Gas Supervisor at this time is to enforce the laws regarding the waste of gas.

Comparatively little was known regarding the natural gas industry when the laws to regulate the use of this fuel were enacted. Enough territory had been developed to show the approximate area of the field, though it was some time before the gas area was definitely defined, if it ever has been. To the consumer who knows nothing of gas except what he sees at the point of consumption, the supply seems inexhaustible. It has been a very difficult task to convince the consumers of this fuel that the supply would not last forever.

Regarding the purpose of the annual reports from this office, it is plain that they are to make public the resources and limitations of the gas field. This I shall endeavor to do, though it must not be forgotten that the work of the office has changed as the conditions in the field have. For the first five years of the history of the field there were no laws to enforce, and if there had been it would have been a difficult task, as it always is, to enforce a law against public opinion. At that time, the time of the Supervisor could be given to the statistics required in the report. As the field progressed and evidences of a decline in the supply became plain, laws were enacted to husband it, and as the consumers of this fuel became educated as to the true conditions in the field, more of the Supervisor's time was demanded in the enforcement of the law. Since I have had charge of the office I have devoted all of my time to the enforcement of the law prohibiting the waste of gas. Incidental to the other work I have been able to collect the data and statistics given in this report. The citizens of the gas belt and the consumers of natural gas in general do not seem to be concerned very much at present about the condition of the

field. It is understood and acknowledged by all that the supply is fast declining and that the end can not be far off.

The changed fuel conditions in the gas belt and other places in the State where natural gas is used has been accepted in a common-sense way by the average natural gas consumer, and where other fuels have not already been adopted arrangements are being made to change. As I have stated, what is demanded now by those interested in the gas industry as well as the consumer, and that in no uncertain tone, is the strict enforcement of the law prohibiting waste. And, since I have not been able to do all of the work stipulated by law, I have endeavored to do that which seems to me is of most importance to the natural gas interests under present conditions.

## THE CONDITION OF THE GAS FIELD.

To make an intelligent report of the condition of this field at this time is indeed a difficult task. It is difficult for any one that has not visited the field to understand the varied conditions that exist at this time. And, not only are they varied but they are constantly changing. During the early history of the field they were fairly uniform. To gain an idea of the condition of the entire field it was but necessary to examine one or two sections. To gain any conception at all of the gas field at this time, and the supply of gas, it is not only necessary to visit and examine every section of the field, but it is equally necessary to understand the general character and location of the gas rock. In this field the Trenton limestone is referred to as the gas rock, but, as a matter of fact, only a small part of the Trenton limestone is gas rock. The gas rock is that part of the Trenton limestone that has the textural condition necessary to a gas reservoir; that is, that is porous. It neither comes to the top nor extends to the bottom of the Trenton formation. It is usually found from one to fifteen feet from the upper surface of the Trenton rock and is from one to fifty feet thick. In a few instances it has been found thicker than this, but there is seldom over fifty feet of continuous gas rock. Both surfaces of this rock are very uneven, as the records of many deep wells testify. At no place has the surface of this rock been found level for any considerable distance, and a relief

map of the upper surface would show many hills and valleys, elevations and depressions. As I have stated before, the early history of the field showed similar conditions throughout the entire gas area which remained until the salt water advancing met the lower portions of the overlying strata of hard limestone, completely occupying the gas rock at the lowest points. Thus it is seen how the high places in the gas rock have become sealed one from the other as the stock of gas has been consumed and the salt water has advanced. It is also plain why gas wells on the same farm frequently differ so greatly in rock pressure and volume. Each taps a different reservoir. The conditions stated above are substantially the conditions in this field at this time. Instead of there being one gas reservoir as there was for many years, there are numerous small reservoirs, each completely sealed in by the salt water. The same force that governed the pressure at the beginning governs it now, except that the presence of the salt water did not have to be considered at first as it does at present. The life of the gas in each independent gas-holder depends upon the size of the elevation, the porosity of the gas rock and the consumption as it did with the larger reservoir. It is but reasonable to believe that as the supply of gas diminishes and the salt water advances that the reservoirs from which we are drawing gas now will be divided and subdivided into smaller reservoirs until the supply is entirely exhausted. If the drill strikes the center of one of these small reservoirs or elevations in the gas rock a "gusher" is frequently reported, though it may cease to be a profitable producer in a very short time, and, on the contrary, if the drill strikes a low place in the gas rock the result is evident. From the statements above the reason for the great difference in the life, rock pressure and volume of gas produced by wells located in the same section of the field is plain. Frequently wells located on the same farm vary much in rock pressure and volume of flow. One may continue to produce gas in commercially valuable quantities for a year, while another one-half mile away may succumb to the salt water in one week. There is one element in the gas field with which the gas industry has to contend which has not been mentioned. I have reference to the oil industry. The progress of the same and the part it has played in shaping the history of the gas industry will be noted in another chapter of this report.

In many respects the year just past has been peculiar and much unlike previous years in natural gas history. To understand this a brief reference must be made to the history of the development of the field. For the first three or four years after the field was discovered there was but little systematic drilling. Wells were drilled where they were needed. No heed was paid to waste, and the surplus energy of nearly every city and town in the gas territory was expended in trying to get some one to use the gas. It was not long until pipe-line companies entered the field, and then the drilling and general development of the field by all classes of consumers became somewhat systematic, and remained so until the entire field, north, south, east and west, was tied together with pipe-lines. Pipe-line companies, local gas companies and manufacturers very soon learned the necessity of leasing territory to hold in reserve for future drilling and of planning their field of operations. Sometimes this was a difficult task, as conflicting interests tried to pre-empt the same territory. Plans had to be changed to meet unforeseen conditions. Some of the larger gas companies by extending their lines showed a disposition to control the entire gas area. This was a failure, as the highways can not be pre-empted, and wherever a gas company can obtain a right of way for a pipe-line sufficient well sites can be obtained without serious trouble. However, conflicting interests have usually been adjusted without much difficulty. From the beginning, pipe-lines have been extended year after year toward what was considered the center of the field. Where it was possible wells were usually drilled one-half mile apart, though the distance between wells was never uniform. Frequently small areas contiguous to pipe-lines were left undrilled. This continued until the field was developed, that is, developed according to the plan I have described. When this was done there was nothing left for gas companies to do but to redrill the territory. This is being done. With but few exceptions all the drilling done this year is on locations between old wells, many of which had been abandoned years ago. The average well drilled now would have been considered a failure ten years ago. The per cent. of failures are growing larger each year, and where gas is found the volume of flow is seldom above 500,000 and frequently below this. The drilling this year has been much different from former years because there is absolutely

no system in it; that is to say, locations are not drilled in regular order. Gas companies drill in one section of their territory and then another, wherever the indications for gas are best. Wherever the rock is found high the salt water is not liable to be so bothersome. While, as I have said, the wells obtained now are very small they are, nevertheless, profitable. The iron is usually from old wells and the cost is frequently not much more than the drilling. Then, gas is sold for five times what it was ten years ago. Another incentive to continue drilling, though the wells are small, is the oil prospects. Much of the gas territory is showing oil, and where gas is not found in profitable quantities the well is not always a loss.

There has been a very radical change in the method of selling gas throughout the field this year. Within a comparatively short time after gas was discovered every city and town of any consequence was piped for gas. In a few cities "wide open" franchises were granted allowing the gas company to regulate the price for all time. In most cases, however, the danger of this was foreseen, and a limit to the rates to be charged was inserted in the franchise. At first and for a number of years gas was sold at "flat rates" both in the gas territory and in pipe-line cities with one or two exceptions. The price varied from fifty cents to one dollar and fifty cents per stove. The gas companies prospered at these rates for a number of years. As the supply of gas decreased and the wells became less productive; as the rock pressure decreased and the pipe-line had to be extended each year and compressing stations added, the gas companies began to demand higher rates. This was refused at first in most instances, and the result has been numerous controversies between the representatives of the people and the gas companies. In some places the rates have remained the same until this year, and then they were advanced only when the gas company absolutely refused to supply gas longer at the old rate. At present gas is sold in all of the larger pipe-line and gas-belt cities, except Indianapolis, and there is but little sold there, by meter. On account of the scarcity and high price it is not a universal domestic fuel at present, and of course it never will be again. It is generally used as a cooking fuel where the supply is sufficient.

But little new pipe-line has been laid this year. More line was taken out of the ground than was put in it, and especially is this true of the larger lines. The Indianapolis Gas Company and the Manufacturers' Gas Company of Indianapolis, both supplying gas to Indianapolis for domestic and manufacturing purposes, have quit supplying gas to that city and have taken up their lines to the field. A number of smaller lines have been abandoned. A large amount of pipe-line of all sizes belonging to manufacturers who have either left the gas field on account of fuel or have been compelled to change to other fuels is not being used and will probably be taken up soon.

## Abandoned Territory.

On account of the scarcity of gas in some sections of the State, wells have been drilled in territory that has been abandoned for a number of years. In a few instances these efforts have been to a certain degree successful. Usually small companies have been organized to supply gas to the stockholders only. In one city of the gas belt at least twenty-five wells have been drilled within the corporate limits of the city within the year just past. About three-fourths of these produced a little gas at first, enough to supply from five to fifteen families. About one-fourth of them are producing a small amount of gas at present. In but few instances have these wells proven to be satisfactory investments. I have never advised drilling in such territory. Wells drilled in territory that was overrun with salt water five or ten years ago are sure to meet an early death. There is no provision for the renewal of the supply of gas, and when the territory is exhausted that is the end. Notwithstanding, however, the discouragements in this territory, it is probable that much of the field will be re-drilled. After using gas for fifteen years, the people in the gas belt dislike very much to give it up as a fuel and will exert every effort to prolong the supply. What deceives so many interested in these company wells is the rock pressure. The wells that are drilled now in this territory that was abandoned ten years ago show near the same rock pressure that the territory did when it was abandoned. Those that are interested in these wells judge them by the rock pressure, which is never in any case an index

of the capacity of the well. The open flow pressure is an index of the volume of the well and that alone.

## New Territory.

History shows that the development of the Indiana natural gas field was along natural and rational lines. It is easily understood. Soon after the discovery of gas, pipe-lines from six to twelve inches in diameter, radiating in every direction from the gas reservoir, transported the gas to cities and towns beyond the gas area. Consumers 140 miles from the main gas field were permitted to enjoy this gaseous fuel. Naturally, as the edge of the field where these lines first tapped it began to show signs of exhaustion, the lines were extended toward what was thought to be the center of the field. Seldom was any territory completely developed as fast as the lines were laid. Not only were many well sites left but an occasional area of considerable acreage that seemed comparatively unproductive at that time in the history of the field was passed. By way of explanation it might be said that the productiveness or capacity of a gas well is governed by the porosity of the gas rock. If the rock is very porous and the gas passes rapidly from the gas rock to the well bore, the well will be very productive. On the contrary, if the gas rock is hard and contains but few pores or interstices in which the gas may be held, it will pass very slowly from the surrounding gas rock to the well bore and the well will be less productive. The latter is the condition found in the unproductive area referred to above. It may be said, however, to the credit of this rock, that as a usual thing the wells remain productive longer than they do in the more productive rock. In this connection I will repeat, that this undrilled territory just referred to is supplying most of the well sites this year. Wells are located, if possible, near pipe-lines and as close as possible to the point of consumption, either between wells once productive or in territory that was labeled unproductive years ago. The territory referred to above is usually spoken of as new in the gas field, but it is not so considered in this report. New gas territory is that which has never been drilled or tested in any way until the present time. Such is the territory in the northern part of Grant County and the southern parts of Wabash and Hunt-

ington counties. Quite a large area of fairly productive territory has been developed in that section this year. Some of the wells started with a very large production, and a showing of oil is found in some places. Over one hundred wells have been drilled in that section, and three years ago it was considered entirely out of the gas belt. Huntington, Wabash and Marion are supplied largely from this field this year. This new field, though small, is completely separated from the main gas area, either by salt water or a section of hard nonporous rock, probably the latter. The rock pressure varies from 230 to 280 pounds. The gas rock is very irregular in thickness and porosity. A few "dusters" are to its credit. How long it will continue to supply the present draught I can not say, though every indication is that it will be much shorter lived than the field south.

Since gas became so scarce, it is but natural that considerable "wildcatting" around the edge of the field should be done. Cities are piped for natural gas and all of the appliances for regulating and distributing the same are in place. The consumer has the necessary pipes and heating appliances. Even if other fuels were as desirable as gas, a change would mean a large immediate expense. Under these conditions, gas companies can get any reasonable price for the gas as long as it does not cost more than other fuels. A number of fairly productive wells have been drilled near the extreme northwest edge of the field this year, the product of which is being taken to Wabash and Peru. So far as I know all of the gas companies of the State that are pretending to supply gas are doing their best to give good service, though it is true that some have fallen far short this year even with the limited consumption. In some sections gas companies have expended large sums of money in their efforts to secure an adequate supply of gas, and have failed. In most instances discouragements have been met with renewed determination, and because of this more than one city has enjoyed the privilege of using gas one more year.

About seven years ago a strong flow of gas was found near Petersburg, Pike County. The second well was a failure. A second producer has been recently found. Gas has been used in that city for domestic and manufacturing purposes since the first well was drilled. The flow of the wells and the pressure remain strong considering the consumption. The find at Petersburg stimulated

the desire to find gas in that section of the State. Much money has been spent and many wells drilled without much success except at Loogootee, Martin County, and Princeton, Gibson County. At the former, gas was found at a depth of about 500 feet, four years ago. Twelve wells have been drilled a short distance west of the city. All are good producers and show a pressure after four years' use of 125 pounds. The field is small and efforts to enlarge it have not been successful. Some oil is found. At Princeton but little gas has been found, not enough to be commercially valuable. The oil prospects are bright at this time.

There has been some drilling for gas in Allen County the past year with a show of success, but not enough gas has been found to attract much attention.

## The Consumption of Gas.

The consumption of natural gas both in the field and in pipeline cities has decreased more during the past year than any previous year in the history of the field. To a person who has watched the progress of the field from the beginning it seems that the year 1903 has been a year of changes. More people have changed from natural gas to coal and wood than any previous year, and in the matter of rates the change has been almost universal. Gas is very generally sold in the larger cities by meter measurement, and the change from the flat rate system has, in most cases, been made this year. To benefit by the meter, economical appliances must be used and, since the future of gas is so doubtful, many people have declined to purchase new appliances and are using gas for cooking only. Thus, the use of natural gas for domestic purposes has decreased at least fifty per cent. during the past year.

It is very difficult to say how much gas is used for manufacturing purposes or to compare the amount used now with the amount used when gas was plenty and factories used all they could and wasted nearly as much as they used. Some gas is used by some factories, and none that I know of have enough. One thing is certain, all the gas belt factories are not going to leave this part of the State when the gas is entirely exhausted. The indications now are that but few factories will leave the gas field. Some of the smaller glass factories that have but little invested

in buildings and machinery will probably either quit the business or rebuild near a supply of fuel. Some of the largest and most substantial factories in the field have quit using gas and are seemingly doing a profitable business, using coal. Others are shut down a part of the time on account of the shortage of gas, while a majority are supplementing the limited supply of gas with other fuels. Present indications are that but little gas will be used for manufacturing purposes another year. The first city to abandon the use of natural gas entirely is Logansport.

## The Waste of Gas.

It is hardly possible to say anything about this subject without rehashing what has been said in former reports, for it has been given more space than any other subject for several years. It has been and is a subject of most vital importance to the gas interests of the State. There never has been a moment since this fuel was discovered that it has not been wasted in various ways in every section of the field. After about five years the Legislature of the State took notice of this waste and enacted laws prohibiting the use of natural gas in flambeau lights and the escape of gas and oil from pipe-lines. Every person at all acquainted with the history of the field knows of the large amount of gas that has been wasted by the use of the large gas torches that were allowed to burn night and day, year in and year out. The enforcement of the law prohibiting these lights encountered much opposition at first which was caused largely by the idea that was generally entertained at that time, that the stock of gas was being renewed daily and could not be exhausted, regardless of the amount used or wasted. Of course, as usual, it was contended that the law was unconstitutional. In 1896, the Supreme Court of the State rendered a decision holding the law constitutional. About this time the gas began to show signs of failure and this, with the decision of the Court, has rendered the work of enforcing the law comparatively easy. The only trouble that I have had is to get the necessary evidence to convict the person who uses or lights the light. My attention is called more often to the lights used by drillers and oil well pumpers than any other class of people. Natural gas makes the most convenient light that either can use, and there

would be no objection to its use if it was not wasted. Most of the waste can be charged to carelessness. Imperfect fittings and burners are used and more lights are used than are necessary. I have found the most economical outdoor light to be a jumbo tip enclosed in a perforated iron globe. While these do not, strictly speaking, conform to law, they consume less gas than the lawful light. There have been twenty arrests made by this office during the year for the violation of the flambeau law. Twenty-one affidavits were filed by an officer at Upland not connected with this office against persons using natural gas torches, with four convictions.

Prior to the discovery of oil in the main gas area but little gas was permitted to escape from wells. The amount of gas that has been wasted to test the gas field for oil and to produce oil can not be even estimated. It would probably be a little extravagant to say that as much has been wasted as has been used, but an enormous amount has been wasted, as every person will testify who witnessed the oil excitement in the vicinity of Alexandria, Madison County, in 1897. The records show that over fifty wells, producing from one to five million cubic feet of gas daily, remained open for six months. These wells were closed after the Supreme Court of the United States had declared the law constitutional. From that time until recently there has been a struggle between the oil and gas interests. It has been impossible, even if desirable, to stop the development of the oil industry in the gas field. Oil can not be produced in high-pressure gas territory without wasting some gas. However, the gas pressure has gone to a point now where oil can be produced if the proper precautions are taken, without wasting gas. Most cases of waste that I have found this year could be charged to negligence on the part of the pumper. In fact, in the most productive parts of the oil territory, gas is so scarce that the oil operator is more interested in husbanding it than any one else. There are many places in the oil field where there is not enough gas for fuel for drilling and pumping. While it is not possible for one assistant and myself to be every place at the same time or to visit any one place very often, yet I have learned the sections where the disposition to waste the gas seems most pronounced and have, I think, reduced the cases of wilful waste to a minimum. As the field pressure

decreases, the pressure in the lines becomes less, and with a low-line pressure there is absolutely no excuse for wasting gas anywhere in the field. The surplus gas can always be put in a line at a fair compensation.

Where there is any effort made to keep field lines in repair there is but little waste now, and as the line pressure decreases the waste from this source becomes less. Of course, as long as there is any gas in the lines there will be some waste, and it can only be kept at a minimum by constant attention on the part of the owner. I have endeavored to enforce the law prohibiting the waste of gas from pipe-lines, and believe that I have done effective work along this line this year.

## Plugging of Abandoned Gas and Oil Wells.

Without criticising my predecessor in office in the least, I can say that previous to this year there was but little done to enforce the law regarding the plugging of abandoned gas and oil wells. Both the condition of the field and the reports of the Natural Gas Supervisor show that the subject has needed attention, and doubtless it would have received it had not the law been defective. Numerous attempts to enforce its provisions proved fruitless. The law stipulated the manner of plugging wells and provided an adequate penalty for its violation, but it did not provide any way of ascertaining when a well was to be plugged and, if so, whether according to law or not. A law was enacted by the last Legislature, the provisions of which are given below, that remedies the weak places in the old law and makes it possible for the Supervisor to know whether abandoned oil and gas wells are plugged as they should be or not. Of course, as far as the gas is concerned, much of the damage is done, but a vigorous enforcement of the law at this late day will do much to protect the oil rock. As far as I have been able to ascertain the provisions of the law have been very generally observed during the past year by both the gas and oil interests. I have numerous requests for copies of the law, and for the benefit of those interested who may read this report I give it in full below.

**AN ACT concerning the drilling, operating, maintaining and abandoning gas and oil wells, and prescribing penalties for violations of the same,**

and repealing sections two and three of an act entitled "An act concerning the sinking, safety, maintenance, use and operation of natural gas and oil wells, prescribing penalties and declaring an emergency, approved March 4, 1893," and declaring an emergency.

(APPROVED MARCH 7, 1903.)

Section 1. *Be it enacted by the General Assembly of the State of Indiana,* That before the casing shall be drawn from any well, for the purpose of abandonment thereof, which has been drilled into any gas or oil bearing rock, it shall be the duty of any person, firm or corporation, having the custody or control of such well, at the time of such abandonment, and also the owner or owners of the land wherein such well is situated, to properly and securely stop and plug the same in the following manner: Such hole shall first be solidly filled from the bottom thereof to a point at least twenty-five feet above such gas or oil bearing rock with sand, gravel or pulverized rock, immediately on the top of which filling shall be seated a dry, pine wood plug, not less than two feet in length, having a diameter of not less than one-fourth of an inch less than the inside diameter of the casing in such well; above such wooden plug such well shall be solidly filled for at least twenty-five feet with the above mentioned filling material, immediately above which shall be seated another wood plug of the same kind and size as above provided, and such well shall again be solidly filled for at least twenty-five feet above such plug with such filling material. After the casing has been drawn from such well there shall immediately be seated at the point where such casing was seated a cast iron ball or a tapered wood plug at least two feet in length, the diameter of which ball or the top of which wood plug shall be greater than that of the hole below the point where such casing was seated, and above such ball or plug such well shall be solidly filled with the aforesaid filling material for a distance of at least fifty feet

Sec. 2. The person, firm or corporation owning or having control or custody of any such well or the land in which any such well is situated, shall file or cause to be filed in the office of the Recorder of the county in which any such well is located, within fifteen days after the same has been plugged, as provided in section one, the affidavit of at least two persons who assisted in the plugging of such well, which affidavit shall be recorded in the miscellaneous record books in the office of the recorder of such county, and shall set out in detail the manner in which such well was plugged and the depth of each such wood plugs and iron ball below the surface of the ground, and the record of such affidavit shall be prima facie evidence in any court of a compliance with the provisions of this act.

Sec. 3. It shall be the duty of any person, firm or corporation sinking a well in any oil or gas-bearing rock, or having sunk such well and maintaining the same, to case off and keep cased off all fresh water from such well.

Sec. 4. Any person, firm or corporation that shall, in any manner, fail or refuse to plug a well in the time and manner provided in section one of this act, or shall fail or neglect to secure and file in the proper

Recorder's office the affidavits provided for and required in section two of this act, or shall fail and neglect to properly case off fresh water from such well and keep the same cased off while said well is maintained, as provided in section three of this act, shall be liable to a penalty of two hundred dollars for each any (and) every violation thereof and to the further sum of two hundred dollars for each ten days during which such violation shall continue, and all such penalties shall be recoverable in a civil action brought in any court of competent jurisdiction in any county in which such violation occurred, brought in the name of the State of Indiana on the relation of such county and for the use and benefit of such county, and in all such cases if there be a recovery by the State it shall recover in addition to such penalties a reasonable attorney's fee.

Sec. 5. Sections two and three of an act entitled "An act concerning the sinking, safety, maintenance, use and operation of natural gas and oil wells, prescribing penalties, and declaring an emergency, approved March 4, 1893," are hereby repealed.

Sec. 6. To better enforce the provisions of this act the Natural Gas Supervisor of the State of Indiana is hereby empowered to enter upon any land at any time for the purpose of examining and testing any such well or wells.

Sec. 7. Whereas an emergency exists for the immediate taking effect of this act, therefore the same shall be in force and effect from and after its passage.

## Compressing Stations.

The annual report of the Natural Gas Supervisor for the year 1901 states that there were 41 compressing stations (usually known as pumping stations) in operation in the gas field at the end of that year. The total number of compressors in use is not stated, but it was not far from 100. The same report says: "With the decrease in the rock pressure in the field came the necessity for using compressors on pipe-lines. The pressure required to transport natural gas depends primarily upon the consumption. With no consumption and the pipe-line perfectly tight, the pressure at the outlet of the line must be the same as at the wells, and with the line wide open at the point of consumption the loss of pressure is at a maximum. The amount of natural gas that can be transported in any pipe-line a given distance depends upon the size of the line and the pressure in the same, the former governing the volume of gas and the latter the velocity. Thus, as the field pressure decreases, the question presented to both gas companies and manufacturers is, whether to build compressing stations or increase their pipe-line capacity. Some have adopted the former, others the latter, while occasionally it has been necessary to resort

to both." I agree with this, except that compressing stations were used before the decrease in the rock pressure was sufficient to notice. Where gas was to be transported a long distance, as was the case with the Ohio and Indiana Gas Company and the Indiana Natural Gas and Oil Company, it was necessary to install compressors at the beginning. With the aid of powerful compressors there is hardly a limit to the distance that gas can be transported. For the purpose of protecting the gas territory, the General Assembly that convened in 1891 attempted to regulate the production and transportation of natural gas by enacting a law (Acts 1891, page 89) prohibiting:

1. The transportation of natural gas at a pressure exceeding 300 pounds.

2. The use of any device or artificial process to increase the flow of gas from the wells or for the purpose of increasing the flow of gas through the pipe-lines.

A law enacted by the last General Assembly in substance repeals the act of 1891 except the provision regarding the 300 pounds pressure, and with the present conditions there is little use for it. Though I know it is impossible for any company in the field with the limited supply of gas, to raise the line pressure to the maximum allowed by law, I have tested the pressure in all of the lines transporting gas from the most powerful compressors in the field and have not found the pressure at any place above 200 pounds.

While compressors can be used now without violating any law so long as the pressure is not raised above 300 pounds to the square inch, yet it can not be said that their use is not a detriment to the field. Wherever they are used they have the effect to create a vacuum, not only in the pipes back of the compressor but in the gas rock, and when the pressure is removed from the rock the salt water rushes in and fills the space once occupied by the gas. My observation leads me to believe that where compressors are used in a given territory, the gas rock in the vicinity of the wells under the influence of the compressors soon succumbs to the salt water.

A PHYSIOGRAPHIC AND
ECOLOGICAL STUDY

OF

# The Lake Eagle (WINONA LAKE) Region,

# INDIANA.

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BY W. M. MILLS.

*Prof. W. S. Blatchley, State Geologist, Indianapolis, Ind.:*

Dear Sir—The following report is the result of a summer's work in connection with the Biological Station of the Indiana University at Lake Winona, Indiana. The locality is a hydrographic basin representing a physiographic and ecological unit, and for that reason is one well adapted for a study. During the first part of the summer the class in ecology under Prof. H. C. Cowles, of the University of Chicago, had for their work the tracing of the natural history of the locality along ecological lines, and also to show what was going on at that time in the same line. It was while this work was in progress that evidences were discovered in the physiographic history which seemed to the writer extremely interesting. Accordingly, the physiography was incorporated with the ecology in the report, and the paper is hereby transmitted for publication in the next Annual Report of the Department of Geology.

Very respectfully,

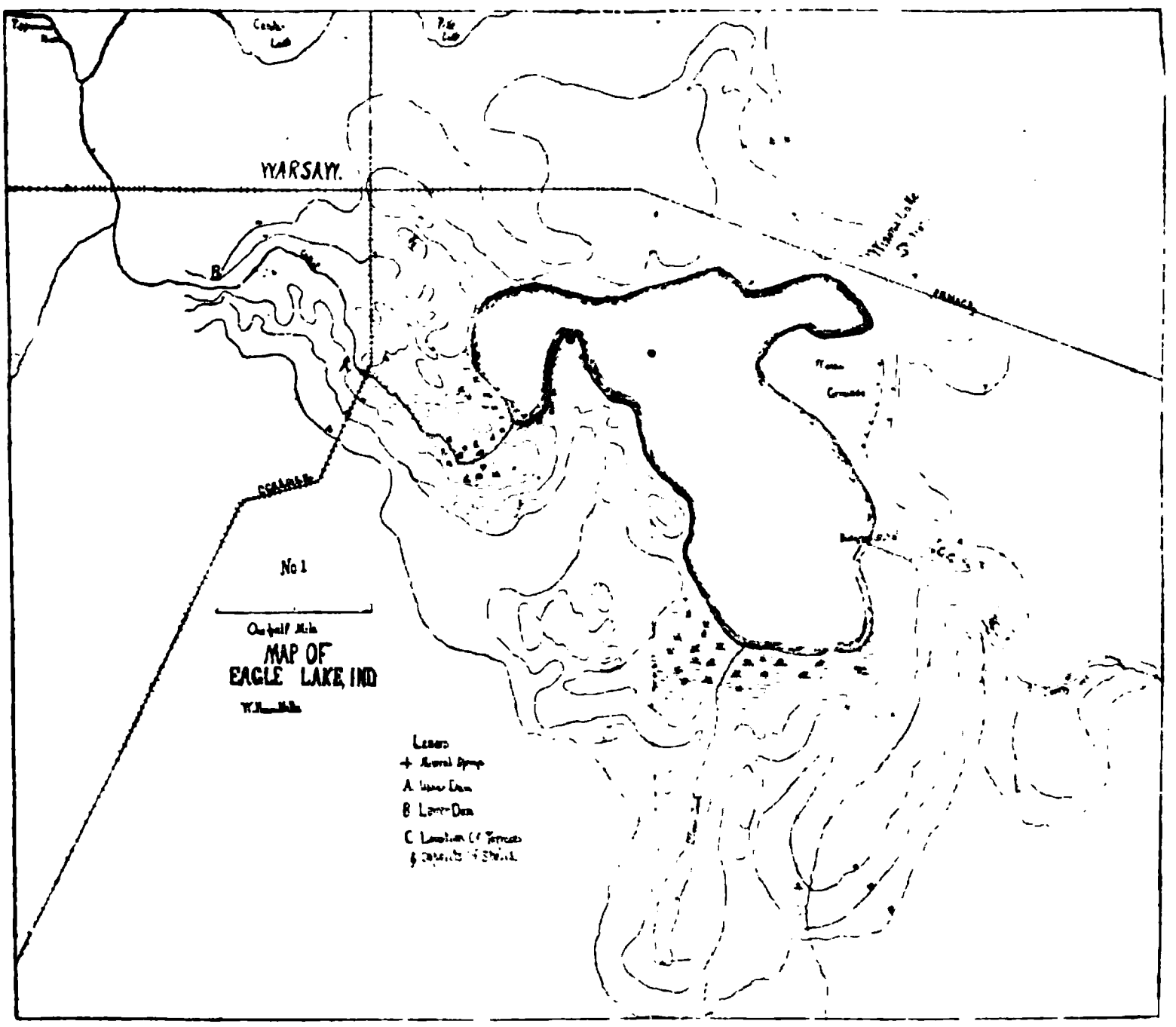
W. MAGOON MILLS.

November 15, 1903.

# A PHYSIOGRAPHIC AND ECOLOGICAL STUDY OF THE LAKE EAGLE (Winona Lake) REGION, INDIANA.

By W. M. Mills.

Eagle Lake, or Winona Lake, which, together with the adjacent area, is the subject of this paper, is located immediately southeast of the junction of the P., Ft. W. & C. Ry., and the C., C., C. & St. L. Ry., in the northern part of Kosciusko County. At present it consists of one main body of water about one square mile in area, although formerly it was much more extensive. The area drained into the lake or "catchment basin" is unusually large




1. Topographic Map of Lake Eagle Region.

when compared with the lake body. The tributary streams are two—Cherry Creek from the southeast and Clear Creek from the south. The amount of inflow from these two streams is quite

insignificant when compared with that supplied by the numerous springs about the lake. These springs, with one or two exceptions, are more or less regularly distributed along the eastern shore of the lake. The outlet is a small stream which leaves the lake at the southern end of the northwest embayment and finds its way, after sluggishly meandering through heavy growths of semi-aquatic vegetation, to the Tippecanoe River, about a mile west of Warsaw.

Recently a canal has been dug, connecting the lake in a more direct way with the Tippecanoe, by which a more effective drainage is furnished. By this means it is intended to drain off the lake water from all the low-lying lands, so that they may be utilized for agricultural purposes. The shores of the lake, in general, are low and marshy, beaches being few and chiefly on the southern and eastern sides. Elsewhere, the shores are overrun by luxuriant growths of aquatic and semi-aquatic vegetation. The bulrush, thriving in extensive beds of peat and marl, is found in the shallow waters of the lake far from the shore. Thick beds of Chara occupy the shallow waters in other places which, together with the heavy beds of water lilies (Nymphaea), and pond lilies (Nuphar) are rapidly reclaiming the lake bottom.

Back from the lake there are elevations of some magnitude and fairly continuous. These are especially developed upon the eastern side, where they frequently rise to heights exceeding 40 feet. It is from this region that the lake derives the major part of its water. The lake itself is not deep, and yet its depth, when compared with that of inland lakes in general, is somewhat striking. Less than a mile in width for most of its length, it has an extreme depth of 81 feet. This lake is typical of the glacial lakes of northern Indiana, all of them having bottoms rather deeper than the elevations of their immediate neighborhood. While the area here is not the "kettle and knob" topography perfect, such as exists at Valparaiso, yet it closely approaches that, the elevations and depressions being formed by the same agencies and largely under the same circumstances. As compared with these lakes, both those in the western States and those formed by glacial agencies in Wisconsin and Michigan are extremely shallow. The majority of the Nevada and Utah lakes, though of great area, average but a few feet in depth.

FIG. 1. A view across the lake from near the outlet. Evidences of the rapid recession of the lake waters are plentiful. Most of the long tongues of rising land are largely beds of Chara and other water plants. Zones of white and yellow water lilies, cat-tails and sedges are seen near the water, while further to the right zones of willow, Carolina rose and osier dogwood merge with the more mesophytic of the forest trees. On to the right is the regulation upland forest. Here is an example of swamp evolution.

FIG. 2. Swamp meadow recovered naturally from the lake and on its southern edge. The forest in the upland back is an oak-hickory one. White oaks occupy the lower part of the slope, the black oaks the higher parts. If left alone, the meadow would become forested. The outer rim of trees are of the mesophytic order, their seedlings being annually destroyed by the mower. Ash, walnut and swamp maple predominate near the meadow.

## The Topography.

Lake Eagle owes its origin to glacial influences. When the ice advance known as the Erie lobe moved southward and westward, it came in contact laterally with that ice advance from the north known as the Saginaw lobe. The median moraine, made up of long, well-marked ridges, is the region under discussion and about to be described. The general direction of this moraine is south 35 degrees west. All the glacial phenomena, once so powerful in forming the surface here, may still be approximately traced by their influences. The region is covered with a very thick mantle of drift, not only the thickest in the State, but much thicker than has been found in the States to the north. At Kendallville, Ind., a few miles to the north, but yet on the summit of the same moraine, the drift measures 485 feet in thickness. From this point south the thickness varies, being 245 feet at Eagle Lake, while at Wabash, 25 miles farther south, it thins out to practically nothing. At this point the underlying rock comes to the surface. This moraine, in which Eagle Lake is located, is one of the six elliptically shaped moraines which at present round the western end of Lake Erie, and which formerly, at successive periods, served to retain the waters of ancient Lake Erie or Lake Whittlessey on the south and which for a long time emptied its waters through the Fort Wayne gap into the Wabash River.

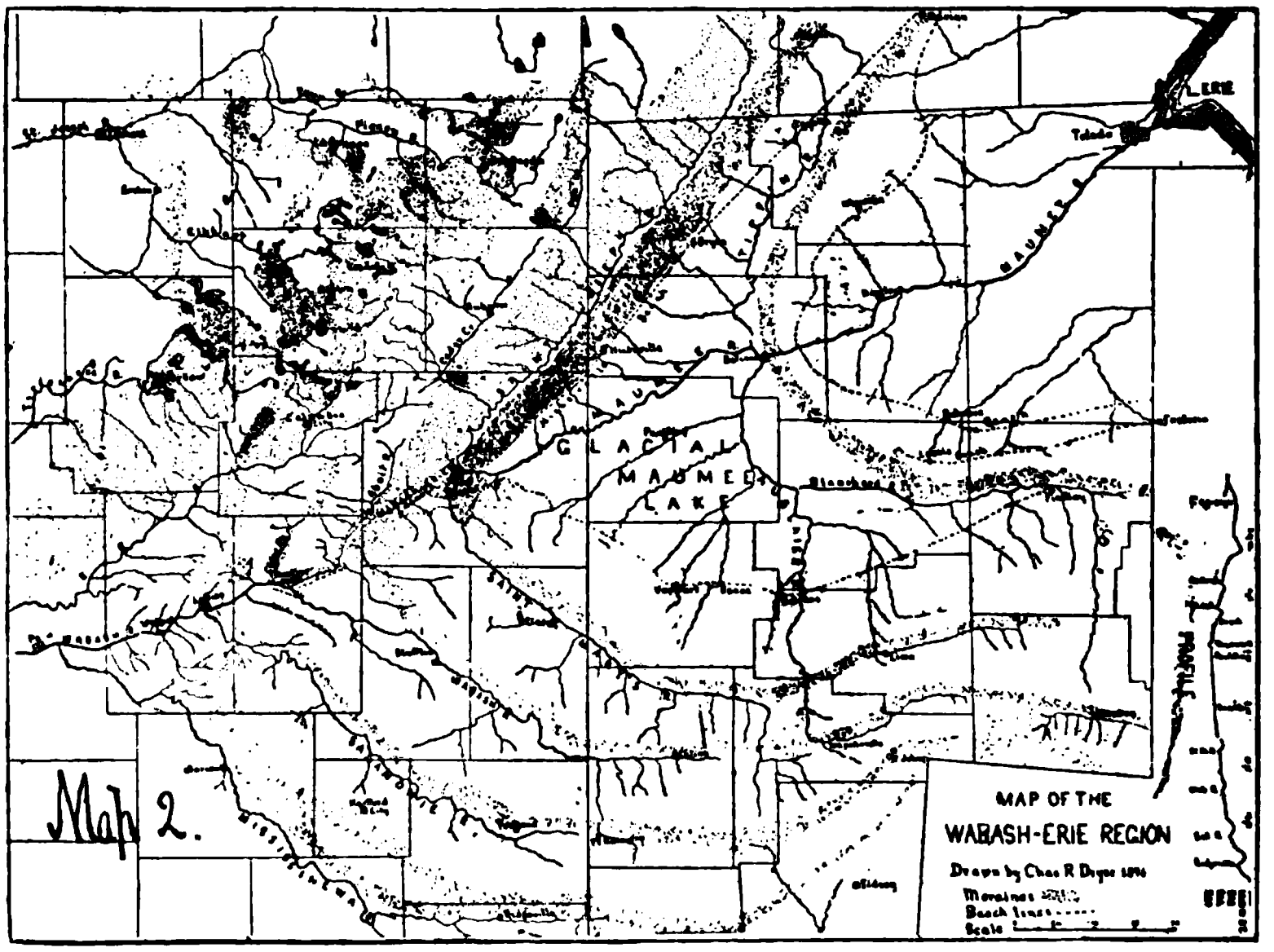
The drift of the region is the regulation glacial till, such as has been observed and studied throughout the glaciated portions of the northern States. The soil content is largely made up of sand and gravel, with a small percentage of clay material. The amount of clay or of the residues or any of the feldspars here is extremely small when compared with that portion of the till of the States farther north. In Wisconsin, for example, and Illinois, the clay is often the chief constituent of the soil, but wherever found near the lake under discussion, it is of a light and soluble nature.

The surface is in general undulating, with here and there an abrupt knob and kettle area. These knobs are dome shaped and the sides are frequently as steep as the material will lie.

The basin or kettle is the exact opposite of the knob, being formed into a deep rounded depression originally by the melting of large masses of ice in the "till." These kettles are, from various

causes, filled with water, and many of them become permanent lakes. Most of the lakes of northern Indiana owe their origin to these depressions in the morainic ridges.

There are several hill-like elevations, probably eskers, scattered over the region, standing usually at right angles to the strike of the drift. A particularly large one, known as Chicago Hill, stands near the Biological Station at Winona. It is, to all indications, a typical esker. It is composed of sand and gravel heterogeneously




2. Glacial map showing moraines in which Lake Eagle and the city of Warsaw are located. (Loaned by Prof. C. R. Dryer and Inland Pub. Co.)

mixed. Its shape is high and oval but not lenticular, and in these characteristics it is neither a kame nor a drumlin. This esker, as well as all of the elevations of the region, has a vegetative covering varying in density according to conditions. As a rule, the slope to the south and southwest, owing to the exposure to the more direct heat in the summer, and consequent drought, bears a type of vegetation approaching what is known among botanists as "Xerophytic." On the northern side of these hills, however, owing to the increased shade and consequent addition of moisture, there is a transition from the Xerophytic vegetation to that type known as "Mesophytic." As these and other ecological terms will be used

more or less in this paper, it will be advisable to briefly explain their significance. In 1895, Warming, a European botanist, adopted these terms in his "Plant Geography." He divided the plants of the world into four great groups; Hydrophytes, or the plants which grow in water or wet places; Xerophytes, the plants which grow in dry habitats; Mesophytes, the plants which grow in places of medium moisture, such as ordinary forests and meadows; and Halophytes, or plants which grow in salt water or alkaline soil. Most botanists have accepted Warming's classification of plant societies as a more or less complete organization of this part of the physiographic-ecological field. The type of vegetation called mesophytic requires protection from the cold and heat in excess, as well as good moisture conditions. The black and white oaks, with an occasional hickory, usually form the forest coverings on the southern and western slopes. As one passes over the crest of these hills, however, a transition in the vegetative types is easily discernible. Descending the northern slope toward the bottom of Cherry Creek near the Biological Station, one first marks the elms. Following the elm comes the aspen. Then the sycamore comes in still lower. As one descends lower the ash prevails. When the hill slope merges with flood plain, the walnut and redbud are more predominant. Along the creek margins, always depending upon the nature of the slope, the hazel, linden or basswood and the willow (*Salix nigra*) occupy the space. The poplars occur here, too, but irregularly. These trees furnish the observer with a direct clue to the topography. It is now well known that each particular topographic form has its own peculiar vegetation. To make direct use of the words of one of the foremost students and authors on the subject, "The reason that the type of vegetation is so closely related to the type of topography is that the soil conditions upon which the plants depend are determined by the surface geology and geography. From the standpoint of vegetation, the topographic relations are more important than the geological. The topographic conditions determine the exposure, the presence or absence of drainage, and the humus content of the soil, and are thus of overshadowing importance. Having related the vegetation largely to the topography, we must recognize that topography changes, not in a haphazard manner, but according to well-defined laws. In all the processes of erosion there is no more potent factor

than that of vegetation. Regarding that, many things may be cited. The peat deposits add greatly to the rapidity with which lakes and swamps are filled, while the plant covering of the hills, on the contrary, greatly retards the erosive processes. As a consequence of all these topographic changes the soils and slopes must change; so that the plant societies which are replaced in turn by others, are adapted to the new conditions."

It will be at once seen that there are mutually powerful agencies at work in an area like this of pronounced topography and strong vegetative influences. The erosive influences are all but balanced by the constructive work of vegetation. Among the various types of elevations the esker, then, represents a unit, both topographically and ecologically. It possesses on its surface trees and undergrowth ranging from xerophytes to mesophytes. Within 150 paces, crossing its crest transversely, one passes from the scrubby black oaks, representing the xerophytic side, to groups of lindens and walnuts representing the mesophytic side. With its elevation of sand and gravel the esker furnishes the necessary conditions of exposure and protection from the rigors of heat and cold and moisture, which determine the vegetative types of its surface. What is here true of the esker is true of other elevations, provided they are of the same soil. A clay hill will differ in its vegetation from one of sand or gravel. However, the topographic relations are more important than the geological, and hence one will observe that the change in vegetation is only a modification.

The vegetative influence on the entire topography is very marked. Located in the belt of heavy rainfall, with an abundance of water in the ground from springs, and in the air from evaporation of the lake's surface, the entire ground surface, with the exception of certain elevations, is covered with a rich herbaceous vegetation and the hills with dense forests. Wherever interfered with, the forests are not luxuriant, but where primeval they are grand in their thickness and deep shade. One stretch of elevation on the 20-foot contour line and back from the lake shore a half a mile, proved a magnificent sight. The trees, nearly all mesophytes, were lordly monsters of the primeval time, towering high above without a limb or shoot. Their bases were deeply covered with mosses and lichens, indicating the extremely favorable conditions for vegetation. Their roots were spread over a great area and, owing to the

wet condition of the ground, they were arched into "knees." The shade of this forest was so dense that only such plants as ferns could prosper. There were many varieties of these, and their long and beautiful fronds grew in heavy clusters. A wagon road had been opened up through one part, and here the Impatiens, nettle, and the Pilea had made haste to get rooted in the rich humus. On the edges of this road the hazel and the redbud had become established. This was a beach-maple forest and these facts illustrate how completely shaded a mesophytic forest's soil is and also how largely all chances of developing undergrowth is shut out from it.

There is no doubt but that a generation ago there existed here the densest and heaviest of woods. Old settlers say that even 50 years ago they were able to take out logs and timbers which, for size and value, rivaled the best of the Michigan forests. The natural undergrowth is so heavy in the open that all lines of drainage are clogged and continually threatened with destruction. In some cases these lines have been artificially reopened, but only to again suffer destruction by vegetative obliteration. Lilies, rushes, cattails and zone upon zone of brush and shrub close in on the lake and continually narrow its confines from the sides and raise its bottom by heaps of debris of the dead plants. One would naturally expect that at the outlet of the lake there would be some or even considerable erosion at the present time, but there is none that is perceptible. It is a case of a stream that has found its valley, not made it. The outlet stream meanders along slowly through dense masses of aquatic and semi-aquatic vegetation, on a slope of exceedingly small gradient, until a point far below the upper dam is reached. Here the erosion setting in from the Tippecanoe is asserting itself, and the gradient increases very rapidly. It seems that the ordinary course of nature, viz., cutting down by erosion and destruction of water bodies by the ascending heads of tributary streams, is here reversed and that, instead, we have forces acting in the opposite manner. This lake, as far as its water body is concerned, would probably remain for thousands of years, vegetation preserving it from any tendency toward destruction by drainage and until the ascending line from the Tippecanoe would reach the lake's margin. This point is now located between A and B on Map 1. At this point erosion is active.

The lake itself presents a rare place for the aquatic plants to perfect their types. The perfection of types, however, and the enormous multiplicity of numbers means, sooner or later, death to the lake itself. The shores, low and marshy, also present the most favorable surroundings for the furtherance of vegetative growth. Great beds of Scirpus skirt these shores and extend far into the lake. Thick beds of Chara and pondweed (Potamogeton) are closer in shore. In intervening places on the marshy shores extensive beds of the pond-lily (Nuphar) with their heavy, soggy stalks and enormous spread of leaves are aiding the other types in raising the lake's bottom with the debris of the dead and dying plants. Back of the immediate margin of the lake, but still in very wet soil, are beds of cat-tail, growing luxuriantly, and beyond these the heavy swamp grasses are established. Then the vegetation increases in height and size and thick zones of brush intervene between the lake and the first line of trees. Among the more plentiful varieties of trees associated with the lake and its life history, is the willow, and particularly the *Salix nigra.* Wherever one may go about the lake's vicinity, these black willows are always in evidence. From the fact that most of them are now in full maturity, their existence there seems to point to a time when conditions differed essentially from the present. Many of them are dying, which also points to a changing environment. They stand for the most part in continuous lines or zones and suggest the preexistence of water lines. They are in their youth associated with running or quiet water, so that now one can say, since they are in full maturity and far from any water, that they once marked the edge of the lake. This inference comes from observation of the habit of the tree and its love for water, for when the spring comes and the young shoots appear, along the water's edge a long line of willow shoots are seen beyond where any other plant has ventured. The seeds of other plants have gone as far, perhaps, but could not endure the conditions and the place has fallen to the willow. Hence it is now generally recognized that a line of willows in natural surroundings indicates a former water line, even though there is no beach line in evidence.

Extending through the mesophytic forests on the low ground about the lake, and especially upon the southern and eastern sides, are numerous lines, in some cases double. These lines are those

FIG. 3. A view looking lengthwise E. and W. of the "Embayment" discussed in the text. In the extreme right winds the main branch of Cherry Creek while on the left may be seen the higher points of the lacustrine beach The vegetation, both of the trees and the undergrowth, is very characteristic of such a slope. The trees vary from the black and white oaks on the left to poplars, sycamores, and elms in the center and the black willow (Salix nigra) on the right. In the left foreground are the bogs mentioned, in which the biological remains are so well preserved.

FIG. 4. View at the point of greatest gradient and erosion in the head waters of the Tippecanoe where the stream has all but succeeded in tapping Eagle Lake. The lake is less than a half mile distant. The view also looks diagonally across the site of the greater dam to the southern abutment. This is 22 feet high at the base of the large white oak in the back. The stones in the foreground are mostly limestones of the till.

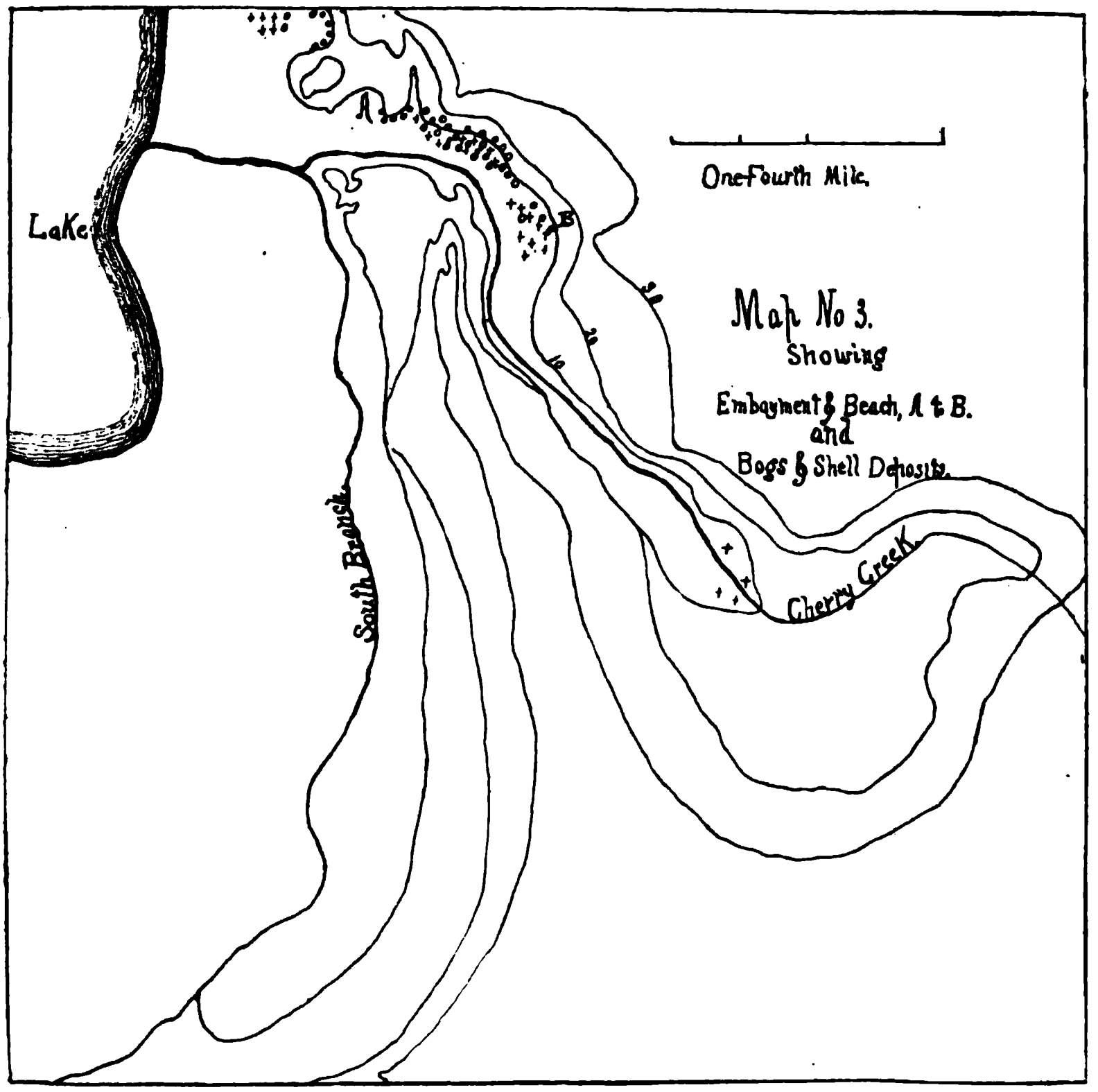
made by willow trees. Between these lines of trees there is an intervening space of about 25 feet. The lines are made up of fully matured *Salix nigra*. These lines are so peculiarly continuous that they seem to indicate the former margin of drainage channels. These lines, representing tributaries, have in the last century occupied many different channels. The streams have wandered at will over old lake bottoms whence the lake water has receded, so that they represent typical flood-plains. It is on these primitive flood-plains that the *Salix nigra* grow in such continuous lines, suggesting the history, at least in part, of the creek and lake. In one small area especially studied, six different oscillations of the channel were observed. In some cases evidence of ecology was corroborated by the still lingering depressions or extinct channels in the ground.

## The Ancient Lake.

About one-fourth mile to the east of Chicago and Hamilton hills, the two eskers mentioned as near the Biological Station, one comes suddenly upon a large and continuous embayment. It is now dry, having no water connection with the lake. Formerly it was filled with an arm of the old lake. Now it has the appearance of a deep and wide valley. Hidden from view by heavy forest growth the valley appears as a case of past erosion at a time when an enormous amount of water went through it. It is impossible to suppose that the present feeble stream which meanders through the deepest parts was ever competent to perform any such amount of erosive work. It seems like placing the Tippecanoe River in the valley of the Mississippi and making it responsible for the valley. The idea, then, that this great embayment was the result of erosion, is clearly unsatisfactory. Neither is it probable that the valley is one formed by river erosion, but one evidently formed by three forces. First, the shape of the topography as left by the glacial ice; second, the erosion which has gone on, both with the creek's aid and by side-wash; third, the effect of lacustrine action and forces which have been long at work and have accomplished much, as will be evident later.

In observing the contour map, it will be observed that this embayment formerly stood by the lake's edge, but the lake has since

evidently receded. As one ascends the depression to the eastward (this depression is 500 feet wide, and more than 2,000 feet long to its southward turn), he will observe upon the left hand a broad sloping beach, extending eastward to the turn mentioned. Its base begins in a line eight feet above the present lake level, and gently and evenly ascends to a height of 18 feet above the lake. It is




3. Map of "The Embayment" and the Cherry Creek Valley.

decidedly lacustrine in shape and formation, and can in no way be laid to river terrace work. Across the valley southward no beach exists; the peculiarity of the formation being that the beach is found only on the northern side. This beach occupies a space betwene A and B on Map 3. It will be seen that this beach, supposing that the lake levels stood as indicated on the contour map, marks the place that would be subject to the strongest wind and wave action. The prevailing winds of this locality being those of

the same latitude, viz., southwest, and there being an expanse of water surface some two miles long, it will be seen how easily this beach might be developed. Remove the present intervening mesophytic forest existing between this point and the lake's margin; raise the lake level over 20 feet, and one can readily imagine what the situation might be and what the opportunities for the development of such a beach were. The ecological factor in proving up the beach is close at hand.

A line of *Salix nigra* of full maturity, about eight in number, skirts the lower edge of the beach, and clearly indicates the former reach of water and of willows. It is plain and sharp in outline, representing a gentle concave curve toward the present channel. At the bases of these trees there is a somewhat sharp declivity of about three feet, indicating that while the level of the water stood here the outlet, for some reason, was suddenly lowered. For the reason that the exact age of these willow trees was not ascertained at the time of the writer's visit here, and no safe comparison can be now ventured between the ages of these and other old trees lower and nearer the lake, it is perhaps better to offer this last evidence with this note. It seems that the line of *Salix nigra* spoken of indicates the former margin of the lake shore. Whether this is from the fact that water was formerly here, and this is what appears to be so, or whether the trees in their growth took advantage of the shape and slope of the declivity is not positive. It is better to use the evidence as corroborative perhaps, to take the evidence of the line of willows with that of the existence of the beach and the deposits of the bivalve shells. The strongest evidence on the point would not be the ecological, nor the geological, but the zoölogical. When once the two latter have been accepted, it is easy to see the place and force of the ecological evidence. Back of this beach formation, the surface rises rapidly and abruptly twenty-four feet above the lake level. Beyond this higher altitudes obtain until heights of fifty and sixty feet are marked by the aneroid.

On a level with the beach and on the northern side of nearly the whole length of the embayment, which is between 7,500 and 10,000 feet long, are numerous springs and peat bogs. These springs and bogs are perhaps among the most remarkable things to be noted in the locality, for from their peculiar nature emanate many other phenomena, such as the preservation of old lacustrine biological

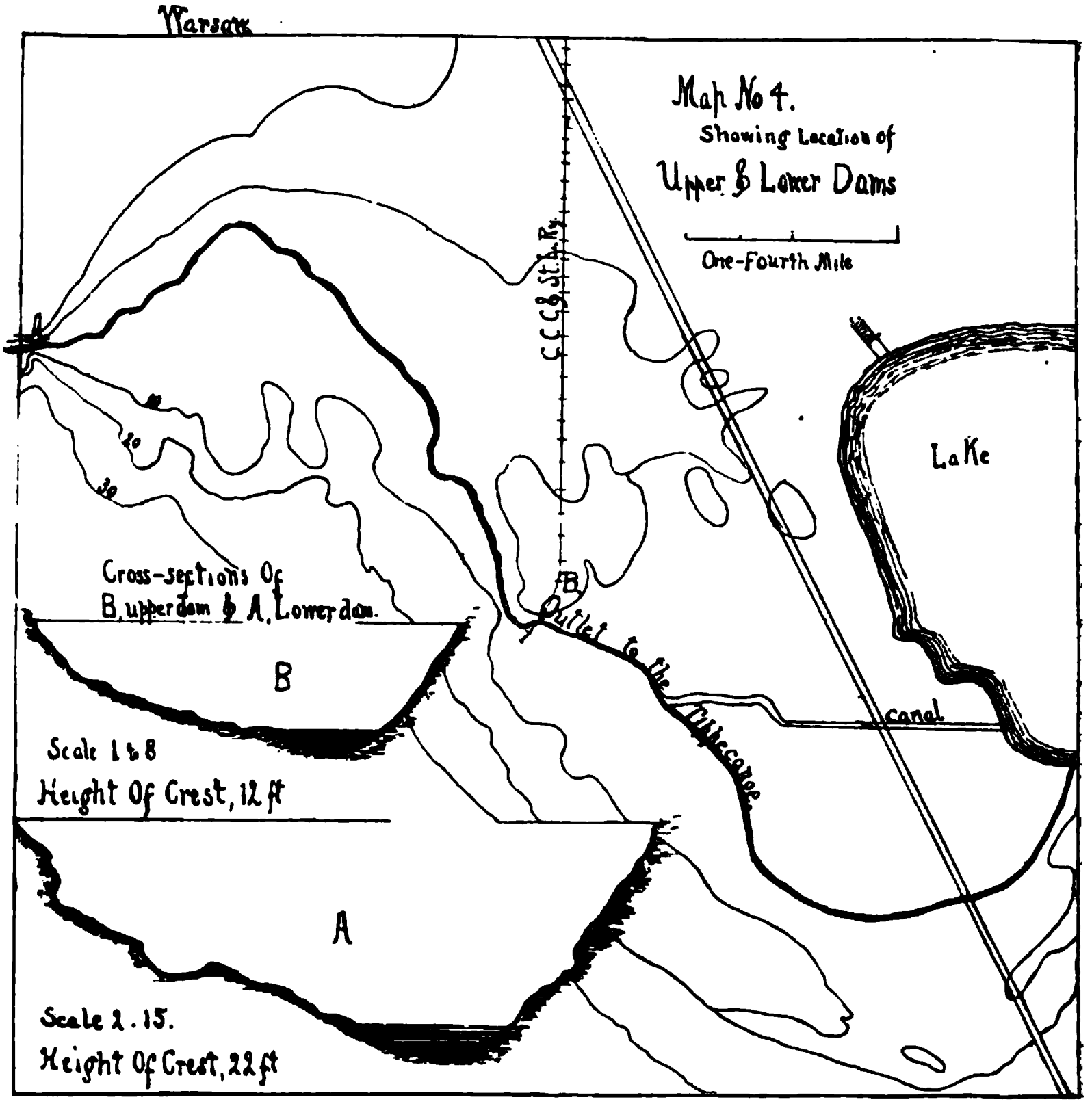
remains and the cementation by their calcareous waters of the glacial sand and pebbles of the bog's vicinity into a conglomeritic mass. This is of course a post-glacial conglomerate. The spring waters, nearly always associated with the bogs, issue from the ground cold and heavily charged with calcareous salts in solution which, upon the evaporation of the water, succeeded in cementing the pebbles and sand particles, among which the water was filtered, into the conglomerate. These masses of cemented rock are found quite plentifully here on the gully slopes and in great hill-side masses at Wabash. For illustration of this see Fig. 6. These spring waters, on entering the lake, have their temperature effectually raised, so that any body with which they happen to come in contact becomes encrusted with limy scales. The plants of the lake, in particular, are acted upon in this manner, and are materially increased in weight and bulk, thereby augmenting the vegetable and mineral deposits upon the lake bottom.

Upon a level with this beach and on the northern side of this embayment are located many deposits of shells and vegetable remains. These deposits are in the bogs before mentioned. The nature of the soil of the bog is such that it will preserve from oxidation and destruction any fossil remains, either of vegetative or animal nature, and especially important for the point at hand, calcareous shells. These shells are those of lacustrine life, hence in these bogs may be found well preserved relics of past years which aid in the interpretation of the natural history of the region. Apart from these bogs the soil has not aided in protecting these plant and animal remains from total destruction either by oxidation or by the root acids in the soil. It is practically a waste of time to search through sandy soil or through soil much exposed to the forces of weathering for remains such as are spoken of, for the reason that they will be entirely consumed in oxidation. In these bogs are large deposits of univalve and bivalve shells. The univalves, although plentiful, do not necessarily give evidence of lake life, for it is well known that they frequent both the waters of lakes and springs. The existence of the univalves in the bogs alone and separate from any other evidence, furnishes only valueless and unconvincing proof, for the bogs are, or have been associated with the springs, but the occurrence of the bivalve shells with them renders the conclusion more certain. The bivalves are, on the other hand,

never found apart from lake life and therefore never in springs, so that the existence of the lake level formerly at this point is demonstrated. It is proven in three ways: First, geologically, by the detailed account of the probable formation of the beach mentioned; second, botanically, by the zones of *Salix nigra* willows lining the beach after their habit and life history is recognized; third, zoölogically, by the numerous deposits of shell life in the bogs now existing on a level with the beach and in close proximity thereto. This one case of verifying scientific theories in the field certainly convinces one of the extreme value of associating the sciences together, especially where they are so closely related as Physiography and Ecology. When a small knowledge of one is once gained, it is next to impossible to rely alone upon the other. Dr. H. C. Cowles, of the University of Chicago, made a visit with the writer to the localities mentioned, and it was apparent that the formations and deposits were due entirely to lacustrine action and that the further evidence necessary to establish the fact that the ancient lake stood at these altitudes and was instrumental in the creation of the evidence cited was, after demonstrating the existence of a 10 and 20-foot contour line around the lake, to locate, if possible, a dam or the remnant of one at the outlet.

The contour lines of 10, 20 and 30 feet are not altogether continuous in the vicinity of the lake, especially on the northern shore. While the surface rises to higher altitudes east of the lake, on the south and west the surface is so effectually broken up by embayments that it is with difficulty that the contour can be traced. Those east and south of the lake are, however, fairly continuous. The 10-foot line is followed with but little difficulty, but the 20-foot line takes in such a vastly greater area that it is necessary to make constant reference to the level and aneroid to establish it. There is no doubt that the 30-foot line would include not only most of the city of Warsaw, but even Center and Pike lakes. On the west the high grounds close in rapidly upon the lake, and since this side is free from tributaries, there are practically no embayments. Of course, at the outlet there is a depression leading toward the Tippecanoe River. This depression, as far westward as the letter B on Map 1, was filled with water when this lake was at its maximum height. This embayment varies greatly in width, and is about one and a half miles long. For the most of the dis-

tance the 10-foot contour line runs close to the channel, the 20-foot line setting back considerably. All of the contours converge at B, which was found to be the location of the greater dam. At A, five-eighths of a mile east and where the 10-foot lines are seen to converge, was found the location of the lesser dam. These dams contained the ancient lake waters.




4. Map of the outlet of the lake with cross cuts of the two dams.

The lesser dam at A, Map 1, if it now existed, would have a crest of 12 feet above the lake waters, and would fill in the valley here north and south. The three contour lines converge perceptibly here on the west, but only the 10-foot is actually at hand. The altitudes go above it, however, on the western side, reaching nearly 18 feet. A heavy mesophytic forest is growing all about the place, both on the heighths and in the old valley, so that any continuous view is impossible. On the eastern side there are two 12-foot hills

which form the eastern abutment. This dam was apparently the last one to give way, and its long continued influence in retarding the ancient waters is distinctly seen all about the lake shore. Indeed, in a way, the effect of this dam was more powerful and enduring than that of the greater one, for while the work of the higher waters was on a more magnificent scale, yet much of their work has long been effaced, while that of the lesser waters, through the longer period of action, has been more pronounced. A great deal of the finest bluff work of the higher waters has been nearly obliterated by weathering, while the work done by the lower waters has been largely preserved by the heavy growth of vegetation upon the lower bluffs and embayments. These lower evidences of lake action may be easily recognized and traced by the willow zones before mentioned.

The larger dam at B has abutments still standing, indicating that when existing it had a crest of 22 feet. It crossed the valley transversely and was much wider and more massive in every way than the smaller dam. Both of these dams were formed by glacial action, the material probably being heaped together laterally in ridges, as indicated by the convergence of the contour at this point. The great beach on the eastern side of the lake was formed while this, the larger dam, was intact. After a length of time had elapsed, the length of which it would be difficult to measure, the upper part of the dam slowly yielded to the overflow, and as fast as it gave way the faster the water flowed through the gap until the cutting reached the bottom. The abutments receded until they reached the steeper slopes of the side hills, where the force of the corrasion was greatly diminished. By this time the bulk of the water of the ancient lake had passed on its way and had reached the Tippecanoe, a mile further to the west. It was at this time, and not until then, that the overflow began on the small dam. The time necessary to destroy this one, although much smaller and retaining a vastly smaller basin of water, must have been very long, even vast, to permit the work which was accomplished by the waves of that long period. When we think of the almost even conflict that is now going on between erosive and constructive forces, with the even deepening drainage lines on one hand and their continued tendency to become obliterated by vegetation on the other, and the many years needed to show progress on either hand, some concep-

tion may be had of the lapse of time between the accumulation of the lake body and the final outflow through the eroded dam. It is interesting to think that the erosion lines seen now ascending the outlet from the Tippecanoe, would have crept up the gradient from the river, and succeeded in tapping the lake at the greater dam whether the crest had yielded to the force of the overflow wear or not. However, it would yet take many years for this danger point spoken of to reach the dam and begin its work. The soil of these dams is, of course, the same existing in other parts of the morainic uplands of the locality, sand and small gravel being the chief constituents.

## The Lake Shores.

The vegetation of the lake and that of its shores is materially affected by the nature of the soil of its bed and margin. The soil at any point is determined by forces and factors in constant operation, chief among which is the proximity to elevated lands. The erosive forces of this area are powerful, both by reason of the rainfalls, which are heavy, and the nature of the soil, which is such as to be quickly affected by water. The amount of detritus removed from the top and side of a hill during the season of heavy rains is enormous, especially when these points are denuded of forests and under-vegetative growth. It is not uncommon to see deep gullies, running to the base of a hill, after a severe rainfall, their whole course lined with deep pot-holes formed by the rush of water and the whirl of the till boulders. The load of detritus spread in a huge alluvial fan at its base will, in many cases, measure 20 cubic yards. When the hill slopes to the lake shore, this eroded material, it will be seen, determines the soil content of the beach, especially where there is no intervention of bottom or marsh. The small amount of clay in the till, owing to its very light nature, is carried away in suspension.

It has been suggested that the stretches of sandy beach of today might be accounted for by the combined forces of wind and wave action, grinding up the glacial pebbles and spreading out the accumulation to form the beach. The occurrence of some of these sand beaches on the northeastern shores, where the southwest winds for most of the year spend their force, might seem to partially cor-

FIG. 5. Sample of Jasper conglomerate found plentifully on the surface around the lake. The specimen is eight inches in diameter.

FIG. 6. Samples of the post-glacial conglomerate found near the mineral springs in Cherry Creek embayment and in large masses at Wabash. The glacial pebbles are resting in a matrix of ordinary sand, the whole cemented by the calcareous water of the springs. It is not easily fractured. The above is now in the geological collection of the Field Museum, where it is unique in being the only evidence of a calcareous conglomerate formed by calcareous springs.

roborate this, but surely a second thought would dispel it. In the first place, no glacial pebbles (quartz pebbles) are exposed to the action of the waves, the accumulation of peat and marl completely covering so heavy and immovable a thing as a pebble. The light, shifting sands consequent on the sidewash and erosion of the adjacent hills kept the marl and peat deposits well under cover in their immediate neighborhood. In the second case, long stretches of sand beach occur on the southern and eastern shores, where the prevailing winds do not cause the waves to beat. There has been some confusion in passing judgment upon this point. A beach on this lake and the other lakes of the neighborhood is either sand or marl, and it should be easy to determine which. It should be easy to distinguish between a beach made up of fragments and particles of shell life which is largely calcium carbonate, and one made up of sand and gravel, mainly the oxide of silica. It is clear then that the origin of these sand beaches is connected with their closeness to the sand and gravel hills and ridges, the change in place being effected by erosion and sidewash, and not in grinding and piling up by wave and wind action of glacial pebbles. A casual inspection of the map of contours should show this.

The stretches of marl beach are in part one of the present enigmas to be cleared. They seem, on close inspection, to consist of particles and fragments of shells from mussels down to univalves. However, when the extreme depth of these marl deposits and beaches, which ranges from two to 20 feet, and the size of the lake together with its life capacity is considered, there certainly seems to be a discrepancy in comparisons. Probably all of the deposit is not made up of mineral calcareous matter from the springs, or of animal calcareous matter, but in addition to both of these there is a third element, viz., the remains of lake vegetation which formerly was, while growing, encrusted with a limy covering. Nothing aside from close chemical examination would satisfactorily determine the solution to the question, whether these extensive deposits depend upon the mineral deposits of the springs, upon the remains of shells, or upon the lacustrine vegetation. The deposits must have covered an area commensurate with that of the ancient lake, for at points some distance from the present lake margin, marl deposits have been found with evidence indicating that they were continuous with those of the present lake. At several

points about the lake, canals have been dug, and in all instances deep beds of marl have been unearthed. There is above this bed a thick, solid layer of peat about a foot and a half in thickness. It would be interesting to compare a chemical analysis of this ancient marl, so old as to have a dry solid bed of peat covering eighteen inches, with one of the present time.

There is in the area here a dearth of the boulders generally seen in the till of glaciated countries. Those that are here are small and do not at all compare with the great masses of them either in Michigan or Wisconsin. Neither do they compare in the variety seen in the fields mentioned. A part of this dearth is due, no doubt, to the greater distance from the original location of the rock outcropping, many being dropped by the way. Again, the reduction in size was probably affected by the increased allotment of time in transit which means, of course, continuance of the grinding process by the ice. The prevailing boulder is dolomite. Then comes the granite, usually very numerous and large in glaciated countries, but here very small. Diabases are few and also quite small. Some jasper conglomerates are to be found scattered on the till surface. One of these appears in one of the accompanying plates.

THE STRATIGRAPHY
AND PALEONTOLOGY

OF THE

# Niagara of Northern Indiana.

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BY EDWARD M. KINDLE.

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# THE STRATIGRAPHY AND PALEONTOLOGY OF THE NIAGARA OF NORTHERN INDIANA.

By Edward M. Kindle.

## PART I.—STRATIGRAPHY.

### INTRODUCTION.

The present paper is the outgrowth of field work done during parts of the field seasons of 1899 and 1902. Considerable collections and many notes on Niagara stratigraphy were obtained during the summer of 1899 while studying the Devonian rocks for the Indiana Geological Survey. Through the coöperation of the United States Geological Survey and the Indiana Survey, the writer was able to spend one month during the summer of 1902 in mapping the Niagara outcrops of northern Indiana, and in making collections of their fossils. Prof. George L. Collie accompanied the writer during the summer of 1902, and Mr. V. H. Barnett in 1899, and to these gentlemen we are indebted for much valuable assistance.

Nearly all of the Niagara outcrops in the northern half of the State have been examined. Particular attention has been given to the Niagara dips which have received such widely different explanations from different geologists.

### TOPOGRAPHY.

The original topography of northern Indiana is almost entirely masked by the drift. Deep well records indicate considerable topographic relief in preglacial times. The thickness of the drift in the vicinity of some of the outcrops shows some of the preglacial valleys to have had a depth of four hundred feet or more. Previous to the coming of the ice sheet the topography of northern Indiana was of a rather rugged type, which probably did not

differ greatly from the topography of southern Indiana. In place of this, we have now a great sheet of glacial till, which has obliterated the ancient valleys, and forms a comparatively level plain. In some sections of the northern and northeastern portions of the State morainal topography varies the general uniformity of level which prevails over much of this plain. In the western part, the gently rolling prairies of Newton and White counties merge into the extensive marshes of the Kankakee.

Randolph County attains the greatest elevation of any part of the area, the highest railroad level being 1,234.4 A. T., which is also the highest recorded elevation in the State. The southern part forms the watershed of eastern Indiana and from it streams flow in every direction. The Wabash, Kankakee and White rivers receive most of the drainage of the Niagara area.

The longer streams have excavated shallow valleys in the glacial till, most of which do not reach down to bedrock. The Wabash Valley, however, cuts through the drift at many localities, and along the upper part of its valley affords many excellent exposures of the Niagara. The Niagara also reaches the surface in Newton and Jasper counties, and in some of the counties to the southeast of the Wabash. In nearly one-half of the counties of northern Indiana, however, the drift is so deep that no outcrops of bedrock occur within them. No outcrops of paleozoic rocks are known in the tier of counties along the Michigan State line.

## STRUCTURE AND CORRELATION.

### VIEWS OF PREVIOUS WRITERS.

The earlier workers on the geology of Indiana generally believed the geological structure of the State to be much simpler than recent investigations have shown it to be. Their firmly rooted belief in the uniformity of the geological structure of Indiana prevented many of them from ever entertaining any explanation of the Niagara dips which would include deformation. Prof. John Collett, for many years State Geologist, says in describing Niagara beds which show dips: "The uniform undisturbed condition of the strata of this and adjoining States, will not allow the presumption of upheaval and such dislocation

of strata as would account for these phenomena."* Starting with the assumption of the "undisturbed condition" of the strata, it is not surprising that Collett was compelled to confess in describing a locality exhibiting tilted beds, that "This quarry is a mystery."**

It will be the purpose of the following pages to show that we have in the Niagara beds of northern Indiana a notable exception to the nearly horizontal and undisturbed condition which generally characterizes most of the other formations of Indiana. A number of theories concerning the structure of the Niagara area and the dips have been advanced, and the more important ones will be briefly reviewed.

*Owen.*—Richard Owen first directed attention to the tilted Niagara rocks of northern Indiana. Forty years ago Owen wrote that he had found, near Delphi, "A local dip to the southeast amounting to 40°."† He mentioned also the sharp dips at Wabash and Huntington.

*Cox.*—Ten years later E. T. Cox, then State Geologist, gave a brief description of these localities, but ascribed the inclined beds to false bedding.‡

Oblique or false bedding on a large scale is an unusual phenomenon in limestones. The seas in which they are deposited are seldom sufficiently shallow to permit the action of currents strong enough to produce oblique bedding. As a possible explanation of the dip, however, the hypothesis of oblique bedding proposed by Cox requires an examination. The history of the discussions concerning the Le Claire limestone of Iowa illustrates the difficulty sometimes met with in discovering positive evidence as to the character of the bedding. Even where true bedding seems obvious, it is not always easy to discover in the strata intrinsic evidence which will entirely eliminate the possibility of false bedding being the cause of the inclined strata.

At a number of localities highly inclined beds, richly fossiliferous, have been observed in contact with barren or nearly barren beds where the evidence of tilting seemed so clear as to require no special comment but for the fact that the oppo-

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*Twelfth Ann. Rep. Ind. Geol. Surv., p. 59.
**Twelfth Ann. Rep. Ind. Geol. Surv., p. 59.
†Ind. Geol. Surv. 1859-60, p. 98, 1862.
‡Rep. Ind. Geol. Surv., 1872, p. 307.

site opinion has been held regarding them. The final test of the false bedding hypothesis comes in applying it to particular cases. Does it afford a satisfactory explanation of such examples as the following? Near Delphi a bed fifteen feet or more in thickness occurs, composed almost entirely of the shells of *Conchidium laqueatum,* one to three inches in length, which is inclined at an angle of 20°. While it is, perhaps, not impossible that such a bed should occur in false-bedded strata, it appears to the writer highly improbable. In the case, however, of strata having a dip of 70° or more, as shown in Fig. 1, oblique bedding can not be considered even as a possible explanation. The materials composing the beds, if piled in layers inclined at such a high angle, could not possibly retain their position. Deformation alone offers a satisfactory explanation for such dips.

*Gorby.*—In 1886, S. S. Gorby* described a considerable number of outcrops showing tilted strata, and announced that they indicated a great anticlinal, "extending entirely across the State," which he called the "Wabash Arch." Many of the dips recorded by the author of this hypothetical arch afford evidence against it. About half of them are east or west dips, while the supposed arch has an east and west axis which calls for north and south dips, and fails to explain the others. Phinney in discussing the "Wabash Arch" points out that the gas well records furnish evidence against it.

*Phinney.*—The tilted strata are, according to Phinney, due to irregularity of deposition rather than to deformation, and he states that "they are to be attributed to the building up of coral reefs and rocky prominences over portions corresponding to the dome and offshoots of the Cincinnati Arch or to inequalities in the sea bottom."** A serious objection to the coral reef theory is the frequent absence or scarcity of corals where the dips are heaviest. Corals are not at all abundant in the Niagara of this region. They have not been observed anywhere in sufficient abundance to form reefs. While inequalities in the sea bottom may be responsible for some of the smaller undulations in the strata, neither they nor "offshoots of the Cincinnati Arch" appear to offer a satisfactory ex-

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*Fifteenth Ann. Rep. State Geol. of Ind , 1886, p. 241.
**Eleventh Ann. Rep. U. S. Geol. Surv., p. 653.

Fig. 1. Tilted Niagara Limestone at McKee Quarry, Kentland, Ind.

Fig. 2. Quarry East of Delphi, Showing Tilted Niagara Strata.

planation of dips of 45° to 75° in the Niagara rocks, which the accompanying photographs show.

*Thompson.*—Maurice Thompson considered the dip to be the result of the disturbance of beds originally horizontal. He states: "The structure of the Niagara limestone does not in the least indicate false bedding."* Thompson accepts Gorby's hypothetical "Wabash Arch," but evidently had a pretty clear understanding of the local dome-like structures in the Niagara. A summary of his views is best stated in his own words: "The arch formed by this upheaval consists of a vast series of low bubbles or cones that make the surface of the Niagara limestone somewhat like that of a sea in a brisk breeze."†

*Elrod* and *Benedict.*—In the same volume with Thompson's paper appeared a paper by M. N. Elrod and A. C. Benedict on a portion of the northern Indiana Niagara area. These authors conclude that the Niagara "cones" which they describe are the result of a variety of cleavage which simulates stratification, and cuts across the original bedding plains.

A second paper by the same authors appeared in 1894, in which they deny that there has been any tilting of the Niagara beds of the Wabash Valley.‡ Cleavage, or a "modified form of joint structure" is the explanation offered of the dips. This hypothesis would deserve careful consideration but for the testimony of the fossils. The occurrence of richly fossiliferous bands, running parallel with the so-called cleavage planes, affords conclusive evidence that they are true bedding plains.

*Ashley* and *Siebenthal.*—Dr. Ashley in his report on Newton County,§ based upon C. E. Siebenthal's notes, mentions the heavy dips at the Kentland quarry and states that "it would almost seem as though volcanic or other agencies had produced an upheaval of a kind seldom found in Nature."**

*Kindle.*—During the summer of 1899 the writer visited a number of outcrops in northern Indiana, and became convinced that the dips of the Niagara outcrops in northern Indiana were not

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*Seventeenth Ann. Rep. Ind. Geol. Surv., 1891, p. 183.
†Seventeenth Ann. Rep. Ind. Geol. Surv., 1891, p. 185.
‡Nineteenth Ann. Rep. State Geol. of Ind., p. 22.
§Twenty-third Ann. Rep. Ind. Geol. Surv., p. 190.
**Twenty-third Ann. Rep. Ind. Geol. Surv., p. 190.

apparent but real dips. Two of the outcrops showing tilted strata which were studied were described in a recent paper.*

*Extent and Composition of Beds.*—The area in which rocks of Niagara age occur extends from the Illinois line in Newton County eastward nearly to the Ohio line, embracing the upper Wabash Valley. Throughout this area the strata are frequently found to be highly inclined. Highly tilted beds occur in Hamilton County, seventy miles south of the Wabash. It is probable that the Niagara rocks in the intervening territory have heavy dips at many localities, but the great thickness of the drift over this area makes it impossible to ascertain whether or not this is true.

The Niagara rocks of this region consist principally of magnesian limestone, often varying considerably in texture and composition in a short distance at the same horizon.

The principal types include dull buff dolomites, light gray sacheroidal dolomitic limestones and two or three varieties of nearly pure limestone. Beds of buffish or gray calcareous shale are sometimes associated with the limestone. Local lenses of sandstone have been observed in the Niagara limestone at some localities. One of these, near Kenneth, has a thickness of five and one-half feet, and is composed of pure white quartz sand containing only a trace of calcium carbonate and iron. The Niagara outcrops show only a small portion of the total thickness of the beds of this group, none of the sections extending down to the Lower Silurian. The information which we have concerning its thickness is derived from well records. From these it appears that the Niagara has a thickness of from 250 to 500 feet.

*Correlation.*—A study of the faunas of the region has shown the presence in it of faunas representing two distinct and successive epochs of the Niagara group. In a previous paper** by the author, the earlier of these faunas as represented at a typical locality was listed, and the fauna was correlated with that of the Lockport limestone of New York. The later fauna which has been recognized contains many species of the Guelph limestone fauna of Canada, which has not hitherto been known to occur in Indiana.

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*Am. Journ. Sci., Vol. XIV., 1902, pp. 221-224.
**Am. Jour. Sci., Vol. XIV., 1902, pp. 221-224.

The beds holding the earlier fauna are perhaps better exposed at Connor's mill on the bank of White River in Hamilton County than anywhere else in northern Indiana. They will be called, from the township in the northeast corner of which they outcrop, the *Noblesville dolomite.* The rock is a hard, thin-bedded, buff-colored dolomite lying in strata three to ten inches thick, of which there are 25 feet or more exposed at the type-locality. Just what the total thickness is which should be included in this division of the Niagara can not be stated, since the upper and lower limits have not been seen in any single section; it is probable, however, that this formation includes not less than 100 feet of strata. Faunally the beds are characterized by such well-known Niagara (Lockport limestone) fossils as *Spirifer nobilis, S. radiatus, S. crispa var. simplex, Conchidium multicostatum, Sphærexochus romingeri* etc. No trace of the Guelph fauna appears in it. The faunal affinities of the Noblesville dolomite point to its approximate equivalence with the Lockport limestone. The Noblesville dolomite is well exposed in a quarry southwest of Fishersburg and near Helm's Mill in the southeast part of Hamilton County. The faunal characters are essentially the same at both places as at Connor's Mill, but the dolomite is much softer at the latter point and lighter colored. The Niagara beds at Pendleton are of this horizon, the rock being a soft, drab dolomite, becoming shaly in places. At Delphi the Noblesville dolomite is represented by the outcrops of drab-colored dolomite in the "Old Deer Creek Channel" east of town between Deer Creek and the wagon road. These beds contain *Sphaerexochus romingeri, Cyrtia myrtia,* and other Niagara species without any trace of the varied cephalopod and gasteropod fauna common in the higher beds exposed in the quarries to the northeast.

In the quarries at Huntington is found a fauna of later age, and very different from that of the Noblesville dolomite. The bulk of this fauna consists of a congeries of cephalopod and gasteropod species, mostly of large size, together with a few heavy-shelled brachiopods. Only four of the fifty species of brachiopods which occur in the Niagara rocks of northern Indiana have been recognized in the collections from Huntington. Two of these are *Conchidiums,* one of which is a new species; a third is the wide-

ranging *Atrypa reticularis* and the fourth is *Dinobolus conradi,* a species common in the Guelph of Ohio. Only two trilobites have been recognized—a new species of *Encrinurus* and a large *Illaenus* comparable with *I. insignis,* which is associated with the Guelph species in Wisconsin. The cephalopod and gasteropod element of the fauna appears to be of distinctly Guelphic affinities.

This affinity is seen in the presence of *Trochoceras desplainense, Pragmaceras parvum,* three species of *Murchisonia*—one of which is the well known Guelph species *M. bivitata,* and other species which are represented by closely allied forms in the Guelph.

The rock in which this fauna occurs at Huntington is a light gray, or cream colored, granular dolomitic limestone of saccharoidal texture. It differs very decidedly in physical appearance as well as faunal characters, from the dull buff-colored *Noblesville dolomite.* It will be convenient to designate the beds exposed in the Huntington quarries as the *Huntington limestone.* This name was used for the same beds by Cox in the Report of this Department for 1878, p. 66. The total thickness of the Huntington limestone is not known, but it is probably not less than 150 or 200 feet. About 80 feet are exposed at Huntington.

A magnesian limestone similar in physical and faunal characters is seen in the lime quarries northeast of Delphi. The fauna of the *Huntington limestone* at Delphi, as at Huntington, is essentially a cephalopod and gasteropod fauna. Of the eight species of brachiopods recorded from it, four are forms having strong Guelph affinities; these are *Monomorella* sp., *Trimerella* sp. and two varieties of *Pentamerus oblongus.* The latter species, although occurring in the earlier Niagara fauna in New York, is a common form in the Guelph of Ohio and does not appear in the fauna of the *Noblesville limestone* in Indiana.

In the case of the localities which have been mentioned in connection with the Noblesville dolomite and the Huntington limestone, the correlations which have been made are based upon paleontological and lithological data, which appear to be entirely adequate. There are, however, many localities where a scarcity of fossils, or variability of lithologic features have made it impossible in the rapid survey which circumstances necessitated, to secure satisfactory data for correlating the beds with either of the divi-

sions of the Niagara which are here recognized. For this reason the broader term, Niagara limestone, has been generally employed.

*Structure.*—The general structure of the Niagara beds of northern Indiana is that of a broad arch with gently sloping sides trending northwest and southeast. It represents a northwestern extension of the Cincinnati geanticline. Its axis, approximately located, enters the State near Richmond, and passes northwesterly in the vicinity of Muncie, Marion and Peru, and continues north of the Wabash through Cass, White, Jasper and Newton counties into Illinois. On the two sides of this line of maximum elevation of the Niagara the Devonian and Carboniferous rocks dip in opposite directions; in Michigan and Ohio, toward the north and northeast; in Indiana, toward the southwest or south. The following table shows the elevation of the surface of the Niagara A. T. along a line approximately at right angles to this axis extending from Crawfordsville to Auburn, Indiana, a distance of 140 miles.

| | |
|---|---|
| *Crawfordsville | 81 A. T. |
| Frankfort | 463 |
| Kokomo | 778 |
| Wabash | 652 |
| Columbia City | 599 |
| Auburn | 50 |

The arch described above is not the "Wabash Arch" of Gorby, which apparently was supposed by its author to follow the Wabash Valley in eastern Indiana. The tilted beds which were cited as the evidence of the "Wabash Arch" will be shown in another part of this paper to be independent of the above described arch in origin.

*Dips.*—A large percentage of the outcrops throughout the Niagara area is characterized by dips of from 5° to 80°. In a few instances the dips represent cleavage planes. In one case (at the Means quarry, Newton County) both cleavage and bedding planes are well defined and nearly at right angles to each other, both being inclined at a high angle to the horizontal. A few localities have also been noted where the dip is the result of irregular or false bedding. But the great majority of the dips can be referred to neither of these causes. They are clearly the result of the deformation of strata which were originally horizontal.

*The figures given above are based upon gas well records published in the 16th Ann. Rep. Ind. Geol. Surv., pp. 217-268.

A brief study of the tilted beds will suffice to show that they are not referable to ordinary anticlines. A description of the beds near Kentland will illustrate this. At the Means quarry (N. E. of N. W. of sec. 25) the rock is a hard gray limestone, very fine grained, in strata 3 inches to 25 inches in thickness, dipping N. 60° to 65°, with strike of N. 82° E. At the McKee quarry, less than half a mile to the east, the strata dip 70° to 75° toward the east, with a strike of N. 12° W., or nearly at right angles to the strike at the Means quarry.

Numerous exposures of the Niagara limestone occur near Delphi, which show dips of from 10° to 45°. The dips here, like those at Kentland, do not conform to an anticlinal structure, but appear to be quaquaversal.

*Domes.*—At Wabash a fine exposure of the Niagara occurs near the railroad station which affords a key to the puzzling dips at Kentland and other points where only small exposures can be seen. A railroad cut has exposed a cross-section through the center of a small dome in the Niagara limestone and shale. In passing through the cut the beds are seen dipping in all directions from the center. On the northeast, east and south of the dome, the Wabash River has denuded the dome of superficial deposits and the beds are seen dipping sharply in these several directions as shown in the accompanying photographs. At the south end of the cut the strata dip 25° to 30° S. 40° W. Toward the north end of the cut they are seen dipping to the northwest and north. On the east side the dips are east and southeast. The width of the dome from north to south exposed in the cut is about 840 feet. A portion of the south side of the dome has been removed by erosion. It is estimated that the total north and south diameter has been about 1,150 feet. The excavation for the railroad gives a continuous exposure of the Niagara shale and limestone for half a mile form the center of the dome. The dips of the beds going north from the center of the dome are observed to drop down gradually from a maximum of 30° to perfectly horizontal beds. No dip or other disturbance is noticeable in the half-mile exposure north of the dome.

A group of small domes occur in the Wabash Valley near Lagro. One of these, known as the Hanging Rock, is situated about one mile southeast of Lagro. It consists of a mass of limestone and

Fig. 3. Cross Section of Wabash Dome.

Fig. 4. East Side of Wabash Dome; Strata Dipping East and Southeast.

shale which rises abruptly from the bank of the Wabash River to a height of about 80 feet. The beds exhibit quaquaversal dips and represent a part of the dome the north and east sides of which have been cut away by the river. The upper beds dip to the south and west at an angle of 25°. The lower strata are less inclined.

At Huntington a large area of Niagara limestone is exposed at the quarry one mile east of town. The beds here exhibit quaquaversal dips and indicate a dome having its center within and near the east side of the area exposed by the quarry. The highest dips noted here are 35° or 40°. The exposures are not sufficiently extended to determine the exact diameter of the dome, but from the horizontal strata exposed in nearby outcrops, it is probable that it does not exceed 2,000 feet. At the old quarry, a quarter of a mile northeast, the strata are horizontal.

The quaquaversal dips show a general tendency to drop rapidly from a high inclination to nothing. This is noticeable at the quarry half a mile west of Huntington. The beds in the new quarries on the north side of the railroad show a dip of 25° to the south, while the strata in the old quarry, not more than 100 yards away, show dips of from 1½° to 0. It was doubtless the proximity of outcrops showing highly tilted strata to those of horizontal beds which led Owen* into the error of reporting tilted Devonian rocks at Huntington resting unconformably on horizontal Niagara beds. There is no evidence of either Devonian beds or unconformity in the vicinity of Huntington.

It has been shown that the dips observed in at least three localities are quaquaversal and the expression of dome structure. Nowhere in the area does the strike and dip of the beds conform to an anticlinal or synclinal structure. The dips seem everywhere to be quaquaversal, and it is believed that all of the tilted Niagara beds of northern Indiana represent small domes similar to those at Huntington and Wabash.

*Origin and Age.*—There is at present no positive evidence as to the nature of the forces which produced the domes. It seems probable, however, that they may be analogous in origin to the "mud lumps" at the mouth of the Mississippi. From a recently

*Ind. Geol. Surv., 1859–60, p. 66.

published description of the "mud lumps," they appear to have a similar structure to the Niagara domes. Harris has studied these interesting masses of recently elevated sea-bottom and states, "that they rise up in domes or anticlinals and preserve their regular bedding is proven by their present structure."

Whatever the causes may have been which produced the domes, there is clear evidence that they were developed about the close of the Niagara period. Many of them were elevated above the Paleozoic sea, while others probably did not reach its surface. Some of the domes remained above sea level during a considerable portion of the Devonian age, and there is some evidence that others continued as islands to the end of Devonian time. The evidence of the exposures indicates that the gradual deepening of the Devonian sea which initiated the "Black shale" sedimentation submerged some of the Niagara domes which had remained above sea level throughout the Corniferous and Hamilton epochs. These conclusions are based upon the relations which have been observed to exist between the Devonian and Niagara beds at Delphi, Georgetown, Kentland and other localities. At Georgetown the horizontal Corniferous limestone beds rest on Niagara beds showing a small dip, but there is no evidence of land surface conditions having existed previous to the Corniferous sedimentation.

Near Delphi, at one locality, horizontal beds of Hamilton age. lie unconformably above the Niagara limestone, which shows a dip of 45°; a bed of ferruginous clay and iron ore separates the two. The New Albany shale is seen resting on the Niagara at another locality near the one last mentioned, the ferruginous clay separating these two as in the first instance.

The highly tilted beds near Kentland occur on high ground in the open prairie, remote from any stream. Rocks of later age have been encountered at much lower levels in all directions from this point, within two or three miles, and it appears probable that the Kentland dome remained above sea level until the end of the Devonian or later.

The occurrence of outliers of Mansfield sandstone (Pottsville conglomerate) in the center of the Niagara area of northwestern Indiana near Remington and Jasper indicate that a subsidence occurred after the formation of the Niagara domes in northwestern Indiana which submerged all or nearly all of the Niagara area

Fig. 5. Northeast Part of Wabash Dome; Strata Dipping Northeast.

Fig. 6. Southwest Part of Wabash Dome; Strata Dipping Southwest.

of that region beneath the Carboniferous sea. The development of the present Niagara arch in northwestern Indiana was, therefore, of much later date and independent of the formation of the Niagara domes. While the domes date back to the end of the Niagara, the Niagara arch is of Carboniferous or post-Carboniferous age.

The Niagara-Devonian unconformity which has been described, though much more pronounced, may be correlated with that which has been recognized in Shelby County,* Indiana, and with the slight unconformity between the Devonian and Upper Silurian which has been recorded by Newberry,† on the east side of the Cincinnati geanticline. The evidence at hand points to a general elevation of the sea bottom at the close of the Niagara in the area around the northern end of the Cincinnati geanticline. The resulting shallow sea was doubtless an important factor in the sudden disappearance of the Niagara fauna and the substitution of the corraline fauna of the Corniferous.

## Area Northwest of the Wabash.

*Newton County.*—The Niagara limestone outcrops at two localities in Newton County. One of these is one mile northwest of Goodland, and the other is about three miles southeast of Kentland. Elsewhere in this county the bedrock is deeply covered by the drift with the exception of localities in section 25, T. 27 N., R. 8 W., where Collett reports outcrops of the Lower Carboniferous.‡

The Niagara limestone has been quarried in a small way northwest of Goodland in the S. E. of the N. W. quarter of section 22. At the time of my visit the quarry was filled with water and only the uppermost layers of the rock were visible. These show a rather soft, buff magnesian limestone. It is too soft to make a very good "road metal" but has been used to some extent in road building and also for foundation work. The strata appear to lie horizontal and are covered by three or four feet of surface clay and soil. The same rock is struck in ditching a few hundred yards to the northwest of the quarry. On the Blough and Conway farms,

*Twenty-fifth Ann. Rep. Ind. Geol. Surv.
†Geol. Surv. of Ohio, vol. I, p. 106.
‡Twelfth Rep. Ind. Geol. Surv., 1882, pp. 59–60.

which are near the quarry, bed rock is encountered in shallow excavations. Apparently the Niagara limestone approaches very near the surface over an area of several hundred acres in sections 22 and 15 T. 27 N., R. 8 W. Fossils are very scarce, but sufficient fragmentary material was secured to indicate the Niagara age of the bed.

Three miles southeast of Kentland, in section 25, the Niagara limestone outcrops on the highest ground in the vicinity. The limestone here approaches very near to the surface over an area of more than one hundred acres in sections 24 and 25. In the surrounding country bedrock is seldom found in wells nearer the surface than fifty feet, and frequently it lies at more than twice that depth. The quarries have been opened at points where the rock outcrops or reaches to within a few feet of the surface. The McKee quarry is the most easterly of these and gives the best exposure of the rock. It is located in the N. E. quarter of section 25, T. 27 N., R. 9 W. In the vicinity of the quarry the limestone outcrops or comes within a few inches of the surface for two hundred yards in a direction corresponding with the strike. The strata dip 70° to 75° toward the west, with a strike of N. 12° W. magnetic. A thickness of about 50 feet is exposed in the quarry. On the east side the rock is a hard gray limestone with a semi-lithographic texture and breaking with a conchoidal fracture; cone-in-cone structure is developed in some of these strata. The texture of the stone changes gradually toward the center of the quarry, and on the west side the beds are composed of soft buff magnesian limestone. A large amount of stone has been quarried here and crushed for road building. The harder beds furnish an excellent stone for this purpose.

A low mound which rises perhaps twenty feet above the strip of prairie separating it from the McKee quarry lies about one-fourth of a mile to the northwest of the latter. Hard gray limestone outcrops along the top of this knoll. The strike here is nearly north and south, but the exposure was not sufficient to measure the amount of dip, which appears to be nearly 90°. The Fidelity Insurance Company is opening a quarry at this locality for the purpose of supplying material for road building. The rock is a very tough, hard limestone of excellent quality for this purpose.

About 300 yards west of the Fidelity Insurance Company's quarry, a quarry has been operated on the farm of Mr. S. A. Means for a number of years. The rock here is similar in appearance to that at the McKee quarry; the dip is 60° to 65° to the north, strike N. 82° E. The strata are in layers 3 to 25 inches in thickness. In one part of the quarry a system of cleavage planes, somewhat resembling bedding, have been developed nearly at right angles to the true bedding. These were doubtless developed by the pressure which produced the heavy dip seen here. Fossils are scarce, but more common than at the other quarries.

Deep wells at Kentland and other points within a few miles to the west, northwest and southwest reach the New Albany shale at depths varying from 80 to 180 feet below the surface.* The top of the New Albany shale at some of these wells is more than 100 feet lower than the Niagara at the McKee and Means quarries. The outcrops of the New Albany shale on Carpenter's Creek, a few miles to the northeast, are also lower. Rocks of Carboniferous age lie at a lower level two miles south of the McKee quarry. This would indicate that the Niagara and Devonian are unconformable in Newton County, as they have been shown to be in the Wabash Valley. The relations observed indicate one or more Niagara domes whose summits and sides remained above the sea during Devonian sedimentation and probably through a part of Carboniferous time.

*Jasper County.*—The principal outcrops of the Niagara limestones occur along the Iroquois River in the vicinity of Rensselaer. Bed rock, which is probably of Niagara age, is also reported in the bed of the Pickamink River. High water covered these outcrops, as well as most of those in the vicinity of Rensselaer at the time of my visit. The beds which could be examined were composed of hard, gray magnesian limestone of good quality for road building.

Collett† reported Devonian limestone overlying the Niagara at the dam in Rensselaer, but this bed was not exposed at the time of my visit.

Niagara beds reach the surface in the highway near the center

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*Collett, 12th Ann. Rep. Ind. Geol. Surv., pp. 53-56. Collett, 23d Ann. Rep. Ind. Geol. Surv., p. 187.

†Twelfth Rep. Ind. Geol. Surv., p. 71.

of section 29, six and a half miles east of Rensselaer, and also at Pleasant Ridge station. The Niagara holds a small amount of petroleum in some localities. In section 35, T. 29 N., R. 6 W., a well 35 feet in depth, on Andy Yoeman's farm, furnishes a small amount of dark lubricating oil.

In the south part of the county the New Albany shale outcrops at intervals for more than three miles along Carpenter's Creek. The "black shale" outcrops begin at Remington, where it forms the bed and sides of the stream, exposing a thickness of 15 feet of bluish black to drab shale. In descending the stream the New Albany shale outcrops are interrupted in the north part of section 24 by exposures of the Mansfield sandstone ("Millstone grit") which forms the bed and sides of the creek at the wagon bridge, three-quarters of a mile northwest of Remington. At this point the creek flows through a post-glacial gorge in this formation. The rock is a coarse buff sandstone, locally conglomeritic, the pebbles varying in size from buckshot to hickory nuts. Geodes five to six inches in diameter occur in it. About forty rods below the bridge the New Albany shale again appears in the bed and sides of the stream. At the forks of Carpenter's Creek the Mansfield sandstone outcrops on the east side of the stream and the New Albany shale on the west side. Further down the stream the two formations may be traced to within a few yards of each other at the same level, but the contact of the two was not observed. The relationship to each other of the outcrops described above seems to indicate that the two formations are unconformable. Apparently the Mansfield sandstone has been deposited in an old valley of erosion in the Devonian shale.

*White County.*—The only outcrops of the Niagara limestone in this county known to the writer occur along Monon Creek. It is well exposed in the bed of the stream just west of the railway at Monon. Both the New Albany shale and the Devonian limestone outcrop at much lower levels a few miles to the southeast. These have been described by the writer in a previous paper.* The outcrops at Monon apparently represent one of the Niagara domes. Collett recognized the quaquaversal character of the dips here and stated that "the strata seem to dip from this point in

*Twenty-fifth Ann. Rep. Ind. Geol. Surv., p. 562.

almost every direction."* The limestone at Monon has been used to some extent for making lime.

Four miles northeast of Monon, the Big Monon Ditch cuts through the Niagara limestone for 3,300 feet. The beds here show a dip of from 30° to 45° toward the southwest.

Just west of Wolcott the Mansfield sandstone approaches the surface. It is extensively quarried for glass making in the S. W. quarter of section 25. The section exposed in the quarry shows:

| | |
|---|---|
| Surface clay | 6 ft. 8 in. |
| Light bluish gray, coarse sandstone with coarse quartz pebbles scattered through it | 25 ft. |

The sandstone is very friable, and in a part of the quarry is but little more than an unconsolidated sand.

## Wabash Valley.

*Carroll County.*—No other county offers so good an opportunity to study the relationship between the Niagara and the Devonian rocks as Carroll. Both the Devonian and the Niagara are well exposed in the vicinity of Delphi. The Niagara limestone is a magnesian limestone, buff or gray, usually very hard, but sometimes showing soft beds.

At the mouth of Little Rock Creek, in the northeast part of the county, the lower division of the Devonian limestone ("Corniferous") is seen resting on the Niagara limestone. Both appear to be horizontal at this point. One mile below this the Niagara limestone outcrops opposite Lockport in the banks of the Wabash. Here the beds show a northwesterly dip of 35°. They show a light gray ragged looking limestone, splitting into irregular fragments by frost action.

At Delphi the Niagara limestone is well exposed in the old Deer Creek channel on the northeast side of town. Just south of the Monon railway in the quarry a thickness of 150 feet is exposed. This is the greatest thickness which has been observed in any single section in the county. The dip here varies from 30° to 40°. This series of beds belongs to the Huntington limestone formation. The Noblesville dolomite is represented by outcrops

*Rep. Geol. Surv. Ind., 1872, p. 303.

between the highway south of the quarry and Deer Creek. Above the upturned edges of the Huntington limestone rests a thin bed of impure Devonian limestone of Hamilton age. A bed of iron ore and red clay eight or ten inches thick lies between the two unconformable beds. In the railroad cut just north of the city high school building the unconformity of the Niagara and the Devonian may also be seen, a thin bed of ferruginous clay separating the two as at the quarry section. In the latter case, however, the Devonian is represented by the New Albany shale, the Niagara at this point having evidently remained above the Devonian sea until the beginning of the New Albany shale epoch or later.

At the lime quarry of Harley Brothers the Niagara limestone shows dips of 10° to 15°, mostly toward the south, although the direction of dip tends to swing round toward the west in the north part of the quarry.

In the quarry one-half a mile northeast of the Harley Brothers' quarry the beds dip 20° to 30° toward the northeast.

The Niagara limestone at Delphi makes an excellent lime and is extensively quarried and burned for this purpose at the above mentioned quarries. Lime was formerly burned from outcrops near the river west of Delphi, but the kilns there have been abandoned.

In Carrollton township the Niagara beds reach the surface in the bed and sides of Little Deer Creek, about 200 yards above its junction with the north fork of Deer Creek. The limestone here is a light gray crystalline rock, apparently containing but little magnesia.

*Cass County.*—Nearly all of the outcrops of bedrock in this county are confined to the bluffs of the Wabash River; the exceptions being those along Pipe Creek and in the vicinity of Adamsborough and Logansport. The Niagara limestone outcrops at very frequent intervals along the Wabash from the Carroll County line almost to Miami County. Small patches of Devonian limestone of Corniferous age occur, but less frequently.

The irregular manner of occurrence of the Devonian outcrops is due to the unconformity existing between the Niagara and Devonian beds. Many outcrops of the latter appear to have been deposited in depressions of the Niagara limestone. An example

of this is seen in the Devonian limestone which forms the bed of the Wabash one-half mile below Georgetown. The Niagara limestone rises from 10 to 20 feet above the bed of the river immediately above and below this point. Just below Georgetown both the Niagara and the Devonian are exposed on each side of the river. From five to eight feet of gray, crystalline Devonian limestone rests unconformably on the Niagara. The line of contact between the two is an irregular one, frequently rising or sagging. On the east side of the river the Niagara dips from eight to sixteen degrees to the east, while the Devonian limestone lies horizontal above it.

At Logansport, the Niagara limestone forms the bed of the Wabash. The Devonian limestone appears above it at a number of points in and near the city. It caps the knoll on which the hospital for the insane is located, and outcrops over sixty acres or more in section 2, southeast of the city. At the last named locality it is quarried and burned for lime by Mr. Harry Lux. It makes a superior quality of lime, which is free from magnesia and whiter than the lime from the Niagara dolomite.

The extensive outcrop at the upper Eel River dam in Logansport shows the following section:

1. Gray limestone (Devonian).....3 ft. 4 in.
2. Bluish clay shale.....2 to 3 in.
3. Hard gray limestone breaking with conchoidal fracture (Niagara) .....2 to 4 ft.

The Niagara beds in Cass County exhibit three well marked varieties of limestone: (1) a hard gray, fine-grained limestone, breaking with conchoidal fracture; (2) a crystalline or semi-crystalline, moderately soft rock, and (3) a buff or gray, evenly bedded magnesian limestone, usually with saccharoidal texture. These three appear to represent local varieties of the same beds. The exposure in the banks of the Eel and the Wabash rivers at Logansport are mostly of the first class. An interesting lens of very pure white, fine-grained sandstone about six feet thick, occurs in the hard gray limestone below Kenneth about half a mile. The lateral extent of the bed is not known, as only a single exposure has been seen at the head of a small ravine entering the Wabash from the north. The stone will make an excellent glass sand.

The second variety of limestone is seen in the outcrops one-half mile above Georgetown, on the north bank of the Wabash, and at a few other localities. These limestones were formed under conditions favorable to molluscan life and contain an abundance of fossils.

The beds which are so extensively quarried at Kenneth belong partly to the third class.

The section exposed in the quarry north of Kenneth Station is as follows:

1. Clay and soil..... 6 to 8 ft.
2. Blue limestone ..... 20 ft.
3. Buff magnesian limestone in strata 10 to 4 in. thick ..... 30 ft.
4. Thin bedded bluish-gray limestone..... 10 ft.
5. Heavy bedded dark gray limestone..... 20 ft.

The beds lie nearly horizontal, showing only slight wavy undulations.

A small amount of number three is used for dimension stone; the remainder is used by the Chicago Steel Company as a flux. Several hundred carloads per week are shipped for this purpose. The blue limestone (No. 4) contains a few fossils, but the other beds are almost entirely barren.

In the quarry on the south side of the railroad near Kenneth, which was formerly operated by Harry Lux, the beds exposed are similar to those of the above section.

At Keesport, three and a half miles east of Logansport, the Niagara limestone is quarried and burned for lime.

*Miami County.*—Both the Devonian and Niagara limestones outcrop on Pipe Creek, near Bunker Hill. Elsewhere in the county the Niagara beds are the only beds outcropping. They show numerous exposures along the Wabash near Peru, and in the bluffs of the Mississinewa River the outcrops are almost continuous from the county line to its mouth. At the old limekiln, one mile above Peru, the Niagara limestone shows a dip to the west of 28°. Some very irregular dips are exposed in a small quarry on the south bank of the Wabash, one-half mile above the railroad bridge, which are due to false bedding.

The limestone is quarried from the bed of the river at Peru, and various small quarries have furnished rock for foundation

work. Much of the stone is of a poor quality. It has been burned for lime one mile above Peru.

*Wabash County.*—The Niagara limestone outcrops in great force along both the Wabash and the Mississinewa rivers. At most of the exposures along the latter stream the beds lie nearly horizontal, but inclined beds occur at a few localities. At the mill dam one mile above Somerset a small stream enters the river, exposing in its bed and sides the highly inclined beds of the Niagara dipping toward the north at an angle of about 30°.

The Wabash crosses the county from east to west, flowing in a valley which, in many places, has been cut into the Niagara rocks. The bluffs, 40 to 80 feet high, which border the valley, afford many good exposures of the Niagara beds. The domes which interrupt the otherwise horizontal beds of the Niagara limestone at many points along the Wabash constitute the most interesting feature of the geology of this county. These have been described in another section of this paper. The occurrence of a group of these domes in the flat plain of the Wabash near Lagro is doubtless due to the fact that their development elevated beds of limestone offering considerably more resistance to erosion than the softer Niagara shales in which the lower levels of the Wabash Valley are excavated.

The exposure at the Wabash dome in Wabash affords the longest continuous section noted in the county. It is as follows:

1. **Drab gray calcareous shale..... 45 ft.**
2. **Bluish gray to buff limestone..... 4 to 10 ft.**
3. **Bluish shale ..... 7 ft.**
4. **Buff dolomitic limestone..... 75 ft.**

In some sections a bluish calcareous shale or hydraulic limestone is exposed. This is seen at the base of the Hanging Rock section. It is said to make a good cement and has been used for that purpose. The limestone at Wabash is extensively quarried for flagstone and foundation stone.

*Upper Wabash Valley.*—Above the Wabash and Huntington County line outcrops cease along the river for about seven miles. Near the forks of the river they reappear, and for more than four miles the Niagara limestone appears at numerous exposures in or near the banks of the Little Wabash. For some distance above

Huntington the channel of the stream is cut in the Niagara limestone. The beds show heavy dips at Huntington which have been described in another part of this paper. The limestone at Huntington makes an excellent quality of lime and is extensively quarried and burned for that purpose. The chemical composition of the stone used for lime is shown in the following analysis:*

| | |
|---|---|
| Water at 212° | 0.50 |
| Silicic acid | 1.50 |
| Lime | 31.92 |
| Magnesia | 7.58 |
| Alumina and ferric oxide | 8.25 |
| Carbonic anhydride | 49.52 |
| Sulphuric acid | 0.34 |
| Loss | 0.39 |
| | 100.00 |

Prof. E. T. Cox refers to the "Corniferous epoch" a bed of sandstone at Huntington. He states that "in Huntington County it forms the upper fifteen inches, close grained and loosely coherent." The bed referred to is probably a thin bed which appears in the quarry just west of Huntington. This bed lies between strata of Niagara limestone and is tilted with them at an angle of 25°. While no fossils were noted in it, its position between beds of Niagara limestone show it to be a local sandstone lens in the Niagara.

Occasional outcrops of the Niagara limestone occur along the south or main branch of the Wabash as far east as the State line. At Markle, Buena Vista and other points, the limestone has been quarried for local use. The exposures near Markle show highly tilted beds.

The Niagara limestone does not outcrop in the vicinity of Decatur, but it is extensively quarried after removing the 15 to 20 feet of drift clay and sand. The quarry at the north side of town shows the following section:

1. Surface clay and gravel..... 19 ft.
2. White, soft, thin-bedded saccharoidal limestone..... 8 ft.
3. Heavy-bedded, white saccharoidal limestone..... 15 ft.

*Geol. Surv. of Ind., 1878, p. 60.

The section exposed in the J. S. Bowers quarry, one-third of a mile northwest of Decatur, is as follows:

1. Gravel and clay ..... 20 ft.
2. Dark gray, very hard saccharoidal limestone with frequent patches of chert in the strata in layers of 5 to 18 in. thick..... 20 ft.

The contrast in color and texture between the limestones at these two quarries is most marked, but they probably expose beds of the same geological horizon and the differences doubtless represent local variations of the stone. The white stone is easy to work, and has a handsome appearance when dressed.

## Area South of the Wabash.

*Hamilton County.*—This county is located slightly north of the geographical center of Indiana. The drift in this part of the State is so deep that the Paleozoic rocks are rarely exposed at the surface. Only a few outcrops occur in the county. The most extensive exposure is the one at Connor's mill on White River, five miles above Noblesville. Two small quarries southwest of Fishersville afford an equally good opportunity to study the Paleozoic rocks of the county. Several days were spent by the writer in collecting from the beds exposed at these two localities.

*Connor's Mill.*—The outcrop at Connor's mill consists of a hard, light buff dolomite, which is exposed for two or three hundred yards below the dam. The beds show a dip of from 20° to 40° to the southwest. Above the dam one-third of a mile the limestone outcrops again, dipping 30° to the northwest.

The following is a list of fossils collected from beds exposed below the dam:*

*Favosites favosus* ..... r.
*Streptelasma cf. calicula*..... r.
*Amplexus shumardi*..... r.
*Eucalyptocrinus cf. crassus* ..... r.
*Conchidium multicostatum*. ..... a.
*Conchidium sp*..... r.

*The list here given is a revision of a preliminary list published in the Am. Jour. Sci., Vol. XIV, 1902, pp. 221-224.

*Atrypa reticularis* ..... c.
*Strophonella williamsi n. sp* ..... c.
*Leptaena rhomboidalis* ..... c.
*Meristina maria* ..... r.
*Spirifer nobilis* ..... r.
*Spirifer cf. crispa* ..... r.
*Dalmanella elegantula* ..... r.
*Plectambonites cf. sericeus* ..... r.
*Conocardium sp* ..... r.
*Platyostoma cf. niagarense* ..... c.
*Spherexochus romingeri* ..... a.
*Calamene vogdesi* ..... c.
*Illaenus insignis* ..... c.
*Phacops cf. pulchellus* ..... c.
*Encrinurus americanus n. sp* ..... c.

*Fishersburg Quarries.*—Southwest of Fishersburg one-half mile a very pure, white sandstone has been quarried for glass making. It is a fine-grained, massive, loosely cemented rock, crumbling easily. A buff dolomite, having the same lithological characteristics as the outcrop at Connor's mill, rests upon the sandstone. The line of contact between the two formations is clearly shown in the quarry, and is seen to be a very irregular one, resembling unconformity. The sandstone is believed, however, to be a local lens. Such lenses are known at other localities in the State where both the upper and lower contact with the Niagara is clear. The limestone on either side of the projecting mass of sandstone extends below the surface of the pool which fills the quarry. The limestone beds show a dip of about 35° to the north.

The following section is exposed at the east pit:

1. Surface clay ..... 2 ft. to 18 in.
2. Buff magnesian limestone ..... 1 ft. to 0
3. Hard, fine-grained white sandstone..... 5 ft.

A careful search failed to discover any fossils in the sandstone.

The fauna of the limestone, as well as its physical characters, indicate that it belongs to the same formation as the beds at Connor's mill.

A comparatively short time was spent in collecting from the Fishersburg quarries, and for this reason the following list of fossils from that locality include fewer species than the preceding list:

*Streptelasma cf. calicula*.....r.
*Favosites niagarensis*.....c.
*Spirifer cf. radiatus*.....r.
*Conchidium multicostatum*.....a.
*Reticularia sp*.....r.
*Orthothetes subplanus*.....r.
*Stropheodonta sp*.....c.
*Meristina maria*.....c.
*Nucleospira pisiformis*.....r.
*Leptaena rhomboidalis*.....r.
*Spirifer nobilis*.....r
*Illaenus insignis*.....r.
*Spherexochus romingeri*.....r.
*Phacops cf. pulchellus*.....r.
*Encrinurus americanus n. sp*.....r.

In the southwest part of the county the Niagara dolomite comes near the surface in sections 5, 6 and 32 on the north side of the Fall Creek. A small outcrop of hard gray limestone occurs at the roadside about one-half mile northeast of Helm's mill. Just north of this a small amount of stone has been quarried on Samuel Patterson's land. The quarry has not been worked recently, and only ten inches of buff dolomite are exposed.

A small amount of stone for local use has been quarried in the southwest quarter of section 32, T. 17 N., R. 6 E. The excavation exposes about two feet of thin-bedded, light orange colored magnesian limestone with from two to four feet of stripping.

Outcrops were reported along Duck Creek by Brown,* but a careful search failed to locate them.

*Correlation.*--Richard Owen described the outcrop at Connor's mill in his report published in 1863,† but offered no opinion as to the age of the bed. The earliest reference to the age of these beds occurs in a report on the geology of Hamilton County** by Dr. R. T. Brown, who considered them to be of Devonian age. No paleontological evidence was offered in support of this opinion, the author of the report stating that "the outcrops of rock in Hamilton County are quite barren of fossils." In 1901 the limestones at Connor's mill and near Fishersburg were referred by the writer‡ to the Niagara, but the paleontological evi-

*Rep. Ind. Geol. Surv., 1884.
†Rep. Ind. Geol. Surv. for 1859-62, p. 102.
**Fourteenth Ann. Rep. Ind. Geol. Surv., 1884. p. 27.
‡Twenty-fifth Ann. Rep. Dep. Geol. and Nat. Res. Ind., p. 599.

dence for this determination was not given. The faunal lists here given clearly show the Niagara age of these beds. The Lockport (Niagara) limestone is their probable equivalent in the Niagara group. As stated on a preceding page the local name Noblesville dolomite has been given to these beds.

The Hamilton County outcrops are the most southern exposures in the State which show highly tilted Niagara strata. The orogenic disturbances, which caused a general tilting of the Niagara rocks in northern Indiana previous to the beginning of Devonian sedimentation, did not affect the southern portion of the State, where they lie nearly horizontal, and are conformable with the Devonian rocks. North of the Ohio River eighty miles the Niagara rocks are slightly unconformable with the Devonian,* but nearly horizontal. The Devonian rocks have not been observed in contact with the Niagara in Hamilton County, but it is very probable that they are unconformable, as they have been shown to be farther north in the Wabash Valley.

*Madison County.*—The Niagara beds outcrop at three points on the south bank of Fall Creek in the town of Pendleton. These are at the lower edge of town, at the foot of the fall, and on a knoll 200 yards below the fall. The formation is represented at the foot of the fall by a bluish drab calcareous shale or fine-grained sandstone, above which rests the massive Pendleton sandstone (Devonian). The section at the fall is as follows:

| | | |
|---|---|---|
| 1. | Hard gray limestone | 3 ft. 6 in. |
| 2. | Heavy bedded white sandstone | 6 ft. 8 in. |
| 3. | Bluish drab, fine-grained calcareous sandstone or shale | 10 in. |

The beds exposed 200 yards below this section are composed of buff to ash colored soft magnesian limestone and lie at nearly the same elevation or a little higher than the Devonian beds of the above section. It was doubtless the relative elevation of the Devonian and Niagara beds which led Cox† into the error of placing the latter above the Devonian sandstone and limestone in his section of the Pendleton rocks. The buff dolomite contains *Sphaerexochus romingeri, Spirifer niagarensis* and other Niagara

*Kindle, 25th Ann. Dept. Geol. and Nat. Res. Ind., p. 559.
†Eighth Ann. Rep., Ind. Geol. Surv., 1879, p. 60.

fossils in considerable abundance, and belongs to the Noblesville dolomite formation. The beds appear to lie horizontal. The occurrence of Devonian beds at a lower level than the Niagara, in outcrops so near those of the latter, is doubtless due to unconformity.

Niagara limestone of the hard, gray facies outcrops on Foster's Branch four miles below Pendleton. On the north bank of Fall Creek north of Alfonte it is extensively burned for lime.

About two miles west of the Anderson courthouse a quarry has been opened in the Niagara beds on the south bank of White River. The rock is a drab colored limestone, very shaly, and most of the beds are of little value for dimension stone. This quarry has furnished a considerable amount of macadamizing material.

Other points where Niagara limestone has been quarried in Madison County are near Frankton on Pipe Creek and two miles northeast of Frankton, in section 33, T. 21 N., R. 7 E.

*Other Outcrops.*—A single outcrop of the Niagara is known in Henry County. At the Quarry mills, three miles southwest of Greensborough, limestone was formerly quarried and burned for lime. All that can be seen of the bed at present is about two feet of shaly, bluish-gray limestone near the old limekiln. The foundation of the mill is constructed of this stone.

In Grant County numerous outcrops of the Niagara limestones occur along the Mississinewa River below Marion.

Niagara beds are said to outcrop in the bed of White River above Muncie, but they have not been seen by the writer. Mr. Charles Gough, County Surveyor of Delaware County, states that bed rock lies within a few feet of the surface in the following sections:

| | | |
|---|---|---|
| Section 14..... | Township 20..... | Range 10 East. |
| Section 14..... | Township 20..... | Range 9 East. |
| Section 16..... | Township 21..... | Range 11 East. |
| Section 23..... | Township 22..... | Range 10 East. |
| Section 27..... | Township 21..... | Range 11 East. |
| Section 28..... | Township 21..... | Range 11 East. |
| Section 21..... | Township 21..... | Range 11 East. |

A number of outcrops of the Niagara occur in Randolph County. The stone is used for lime and quarried for flagging

and other purposes. The following analysis of the Randolph County limestone is republished from the Report of the State Geologist for 1878, p. 59.

| | *Macksville.* | *Ridgeville.* |
|---|---|---|
| Water at 212°F | 1.18 | 0.90 |
| Silicic acid | 1.20 | 0.70 |
| Ferric oxide | 1.30 | 2.70 |
| Alumina | 4.40 | 3.75 |
| Lime | 45.45 | 45.08 |
| Magnesia | 4.01 | 4.36 |
| Carbonic anhydride | 40.12 | 89.21 |
| Sulphuric acid | 0.27 | 0.44 |
| Combined water and loss | 2.07 | 2.86 |
| | 100.00 | 100.00 |

# PART II. PALEONTOLOGY.*

## BRACHIOPODA.‡

### *Dinobolus conradi* Hall.

Pl. I, fig. 8.

The natural cast of the brachial valve, which is figured from the Gilbert collection, is the only specimen observed. A feature not shown in most of the figures published of this species is a low, indistinct ridge traversing the broad, shallow, longitudinal groove which crosses the muscular plate.

Rare. Huntington.

### *Monomorella sp.*

Pl. I, fig. 1.

Internal casts of the brachial valve of an undescribed species show the following characters:

*NOTE.—Mr. C. L. Breger has assisted in the preparation of the greater portion of Part II and is the joint author of this part of the paper.

For the loan of literature and assistance in the determination of certain species, acknowledgments are due to Dr. C. D. Walcott, Professor H. S. Williams and Prof. C. E. Beecher.

Mr. J. R Gilbert, of Huntington, has generously loaned us his valuable collection of Huntington fossils, a number of which are here figured. To Mr. G. K. Greene we are indebted for the opportunity to compare the northern Indiana species with those in his Niagara collection from Louisville and southern Indiana.

The illustrations are by Dr. J. C. McConnell and Mr. G. S. Barkentin, with the exception of the figures on plate 25, which were made by Mr. Breger.

The *Coelenterata* and *Echinodermata* and parts of some other groups have been omitted from this paper because of the scarcity of satisfactory material in the collections.

‡The student is referred to Bull. No. 87, U. S. G. S., for the synonomy of the species.

Brachial valve semi-circular in outline, uniformly concave; length of largest specimen 75 mm., width 110 mm. The smallest is about half this size. Platform pear-shaped, tapering toward the front. The platform is divided transversely about the middle into two parts by a shallow furrow, bending backward in the middle; the posterior division is subdivded by a similar but less conspicuous furrow at right angles to the first. Two diverging low ridges extend forward from the ends of the transverse furrow. A second pair extend forward from the anterior end of the platform and reach nearly to the margin of the valve. No specific name will be proposed until a more complete description is possible.

Six specimens have been found at Delphi.

### *Trimerella sp.*

Pl. I, fig. 2.

This genus is represented in the collection by a single fragment which is here figured, of the internal cast of the valve of an undetermined species.

Delphi.

### *Crania sp.*

Pl. I, figs. 9, 10.

Shell broadly ovate, truncated posteriorly; apex rather depressed, near the posterior margin. Anterior adductor scars about one-third the distance from the truncated margin to the front. Surface, apparently with fine concentric striæ.

Only one specimen has been seen which is a cast of a brachial valve from Pendleton, Ind.

### *Strapheodonta cf. corrugata* Conrad.

Pl. I, fig. 3.

Shell nearly flat; surface marked by fine, prominent, radiating striæ; these are nearly equal, bifurcating at intervals and crossed by fine concentric striæ. Four or five oblique folds appear on the hinge margin near the extremities of the hinge line. The alternating finer striæ which are said by Hall to characterize the New York forms have not been observed.

A single, well marked specimen from Georgetown.

*Pholidostrophia niagarensis n. sp.*

Pl. II, figs. 13-15.

Shell small, semi-elliptical, highly arched; the height of the convexity equals half the width of the shell. Greatest width between the hinge extremities which are slightly pointed. The very convex pedicel valve rises abruptly from the hinge line. The gibbous umbonal region projects slightly beyond the hinge line, then descends regularly to the front and sides. Beak small and incurved. Brachial valve not seen. Surface with nacreous luster, smooth except near the front, where faint traces of distant radiating striæ may be observed under a strong lens. Inner surface of shell strongly and coarsely punctate.

Two specimens from Little Deer Creek, Carroll County.

*Strophonella cf. striata* Hall.

Pl. I, fig. 4.

Four or five poorly preserved specimens are provisionally referred to this species. Shell resupinate. Strong radiating plications cover the surface.

Connor's Mill, Hamilton County.

*Strophonella williamsi n. sp.*

Pl. I, figs. 6, 7 and 11.

Shell semi-elliptical, length about three-fourths the width; extremities of hinge line mucronate, extending beyond the rest of the shell. Shell profoundly reflexed about the middle of the valves. Pedicel valve near the beak slightly concave; anterior to the concave region the valve is deeply convex; the depth of the convexity is equal to nearly half the length of the shell. Brachial valve nearly flat or slightly convex near the hinge line, elsewhere very convex. Interior with a strong bilobed cardinal process, directed forward. Inner margin of narrow area crenulated on each side of the beak for about half the distance to the extremities. Surface covered with fine, closely arranged, fasciculate striæ in bundles of from five to ten, which are separated by distinct grooves, most of the latter reaching to the beak. Each groove has the width of about two striæ.

This species is readily distinguished from *Strophonella semifasciata* of the Waldron shale by the absence of the strong elevated striæ which characterize the Waldron species.

The species is represented by about ten specimens from Georgetown, Pendleton, Connor's Mill (Hamilton County), and Delphi.

### *Stropheodonta sp.*

A number of casts represent a nearly flat *Stropheodonta* of undetermined species.

Common at Connor's Mill, Hamilton County.

### *Leptaena rhomboidalis* Wilckens.

Pl. II, fig. 17.

Shell semi-elliptical to semi-circular in outline; valves nearly flat or slightly convex on dorsal, and concave on ventral side in posterior portion of shell; abruptly deflected towards the front sometimes at a right angle to the plane of the posterior portion of the shell. Surface marked by numerous strong, radiating striæ. Six to fifteen strong, concentric wrinkles mark the flat portion of the shell.

The species is common, occurring at Georgetown, Pendleton, and at Connor's Mill, Hamilton County.

### *Plectambonites cf. sericeus* Sowerby.

Pl. II, fig. 22.

Shell transversely semi-oval, greatest width of the shell along the hinge line, which is slightly extended in mucronate points. The interior of the pedicel valve shows a strongly marked, bilobed, muscular impression.

The specimens are casts of the interior and show only internal features. The surface is marked according to Hall "by fine striæ which are even and uniform or alternating with stronger ones; striæ increasing in number toward the margin; granulose or papillose, crossed by a few lines of growth."

Two specimens from Connor's Mill, Hamilton County.

### *Orthothetes subplanus* Conrad.

Pl. I, fig. 5.

Shell semi-circular to semi-elliptical, depressed, convex; length of hinge somewhat greater than the width of the shell. A distinct area extends the length of the hinge in both valves. Surface marked by forty to fifty prominent, rounded, radiating striæ which increase both by interstitial addition and by bifurcation; these are crossed by fine concentric striæ.

A few specimens from Little Deer Creek, Carroll County, are doubtfully referred to this species. In size they resemble Whitfield's *O. hydraulicus,* the largest measuring 6½ mm. in length and 8½ mm. in width. They differ from Whitfield's species in having the radiating striæ of nearly equal strength. The shell is rounded at the cardinal extremities and has a very high area. Beak of pedicel valve sometimes twisted.

The species is rare; found at Pendleton and Georgetown.

### *Chonetes cf. cornutus* Hall.

Pl. II, fig. 12.

Shell small, transversely subelliptical; strongly arched in the middle of the shell; length about one-half the width. Hinge extremities pointed and projecting somewhat beyond the sides of the shell. Four to six small spines on each side of the beak. Surface covered by twenty-five or thirty rounded striæ.

Abundant at Bunker Hill and Logansport; one specimen from Pendleton.

### *Orthis flabellites* Foerste.

Pl. II, figs. 3, 4, 5, 6 and 11.

This species occurs in the dolomitic limestones as natural casts having the appearance shown in the figure. The cardinal area of the pedicel valve forms a low triangle. Surface marked by 22 to 30 broad, prominent radii which are crossed by fine concentric striæ.

Comparatively rare. Known from Wabash and Lagro, Pendleton, and Little Deer Creek, Carroll County.

### *Orthis* (?) *subnodosa* Hall.

Pl. II, fig. 7.

The species is represented by two pedicel valves.

Hinge line somewhat shorter than the width of the shell; area with triangular foramen extending to the beak; beak slightly incurved. A shallow undefined mesial depression extends from the beak to the front bearing two or three plications. Surface marked by fifteen to eighteen bifurcating plications, which are crossed by fine lamellose lines of growth. The shell shows traces of fimbriate surface markings in the best preserved portions.

Rare. Little Deer Creek, Carroll County.

### *Dalmanella elegantula* Dalman.

Pl. II, fig. 9.

Pedicel valve strongly convex, brachial valve nearly flat, longitudinally concave in the middle. Beak of the ventral valve incurved over the high narrow area. Surface covered with fine, radiating striæ.

Rare. Found at Georgetown, at Little Deer Creek, Carroll County, and Helm's mill, Hamilton County.

### *Rhipidomella hybrida* Sowerby.

Pl. II, fig. 8.

Shell rather small, suborbicular, valves nearly equal. Pedicel valve gently convex; brachial valve moderately convex, but with a flat or depressed area along the middle. Surface marked by fine, closely-set, bifurcating striæ arching upwards on the sides of the posterior portion of the shell.

The species is represented by natural casts in the dolomitic limestone showing the impressions of the cardinal teeth and strongly marked muscular areas. Length and breadth apparently equal.

The species is common at Wabash; it occurs rarely at Pendleton, Little Deer Creek (Carroll County), Big Monon Creek (White County), and at Connor's Mill (Hamilton County).

### *Rhipidomella circulus* Hall. ?

Pl. II, fig. 16.

A couple of specimens referred doubtfully to this species are subcircular in outline, slightly broader than long, and moderately convex. Surface covered with fine radiating striæ.

Rare. Georgetown.

### *Anastrophia internascens* Hall.

Pl. II, fig. 10.

Five natural casts of brachial valves represent this species in the collection. These exhibit the following characters:

Valves gibbous, width slightly exceeding the length; surface marked by from 13 to 17 radiating, angular plications, which occasionally increase by intercalation or by bifurcation; fold not well defined, marked with five or six plications. A short, thin septum is present on each side of the beak.

Rare. Found at Wabash and at Pendleton.

### *Conchidium laqueatum* Conrad.

Pl. III, figs. 1, 2; Pl. IV, fig. 3; Pl. VI, figs. 1, 2.

In mature, well preserved specimens with both valves in conjunction, the shell is trigonal or trapezoidal, ventricose and with the depth as great as, or greater than, the width. The pedicel valve is larger and more gibbous than the brachial, the latter being merely operculate. The former valve is elongate, the ratio of length and width being 3:2, with the greatest width in front. The beak is hooked down so that its tip is in the plane of the hinge line. The depth of the valve is equal to half the length, the greatest depth being one-third the distance from the beak to the anterior margin. The lateral portion of the shell is abruptly deflected to meet the hinge line, thus producing a high, rather concave face on each side of the valve. The surface is marked by from 22 to 32, but usually 28 rounded or subangular plications which disappear as the lateral faces are approached. These faces and the umbonal quarter of the ventral valve are smooth except for a few concentric wrinkles of growth, which are very obscure. The delthyrium is equilaterally triangular and extends to the tip of the beak.

The brachial valve is smaller, less elongate and less robust than the pedicel valve. Whole specimens are pentagonal, with the greatest width at the anterior margin. The beak is obtuse and curved down, so that its tip is below the plane of the hinge line, while the umbonal region is concealed in the delthyrial opening of the pedicel valve. This concealment, when both valves are conjoined, makes the brachial valve seem to be smaller and flatter than it really is. The surface markings are about the same as those of the pedicel valve except that the lateral smooth faces are perceptibly lower than those in that valve. Internal casts are marked by two parallel septa, about three millimeters apart in the middle of the valve. These septa extend three-quarters of the length of the valve and diverge only very slightly. The dental sockets are long, parallel to the margin, and diverge at an angle of nearly 90 degrees.

Abundant. Delphi, Big Monon Ditch (White County), Huntington and Georgetown.

### *Conchidium cf. littoni* Hall.

**Pl. III, figs. 3-6; Pl. IV, figs. 1, 2, 4; Pl. V, figs. 4, 5.**

**Pal. New York, III, 1859, p. 262.**

"Shell ovoid, somewhat elongate. Dorsal valve moderately and regularly convex from base to umbo; beak almost rectangularly incurved beneath the beak of the opposite valve. Ventral valve very gibbous; beak subattenuate, incurved. Surface marked by about eighteen or twenty simple subangular plications. There is a broad, concave, smooth space on each side below the beak of the ventral valve, and a much narrower space on each side of the dorsal valve."

The specimens here referred to this species are considerably larger and more gibbous than the specimens heretofore figured, but seem to agree in most essentials with the original description given above.

Common at Georgetown.

### *Conchidium cf. multicostatum* Hall.

**Pl. VI, fig 3.**

Several pedicel valves are referred to this species. Beak moderately incurved, valve sloping uniformly to the sides and front.

Surface covered by about thirty-five rounded, closely set plications. Septum extending two-thirds of the distance from the beak to the front.

Connor's Mill, Hamilton County, Ind.

### *Conchidium trilobatum n. sp.*

Pl. V, figs. 1-3.

Shell large, subovate in outline. Both valves strongly trilobed; greatest width at about the anterior termination of the lateral lobes. Brachial valve deeper than the pedicel valve, beak incurved; cardinal slopes not plicated, descending abruptly, almost vertically, to the margin of the shell. A strong sinus on each side of the median line of the shell and extending nearly to the beaks divides the shell into three lobes, the median lobe being broader and much higher than the lateral lobes. Brachial valve with the beak closely incurved, depth about one-half that of the pedicel valve. Lateral sinuses shallow near the beak, deepening rapidly toward the front and dividing this valve, like the other, into three lobes. Surface of the shell marked with 40 to 70 strong, angular, bifurcating plications. Concentric lines of growth cross these at irregular intervals.

Known only from Huntington.

### *Conchidium unguiformis* Ulrich. (?)

Pl. VI, figs, 4, 5.

A single brachial valve is doubtfully referred to this species. The posterior third of the valve is bent nearly at right angles to the rest of the shell. Beak incurved; surface marked by about eighteen strong angular plications, eleven of which reach to, or nearly to the beak; the remainder arise at one of the strong lines of growth. The plications are crossed by sublamellar, concentric striæ.

Rare. Little Deer Creek, Carroll County.

### *Pentamerus oblongus var. cylindricus* Hall and Whitfield.

Pl. VI, figs. 6-10; Pl. VII, fig. 6.

Shell large, elongate-ovate; subcircular in transverse section. Valves more or less distinctly trilobed in the anterior half, rounded or truncate in front; in the latter case a shallow sinus is present

near the front in each valve. Ventral valve deeper and more convex than the brachial; beak arched over the umbone of the opposite valve.

Surface smooth except for occasional concentric ridges of growth.

Common in a single zone at Delphi.

### *Pentamerus oblongus var. compressa, n. var.*

Pl. VII, figs. 1-5.

This variety is distinguished from *P. oblongus* var. *cylindricus* with which it is associated by the great inequality in the depth and width of the shell. The greatest height of the shell is from two to two and one-half times the greatest width. The depth of the pedicel valve is about one and one-half times that of the brachial valve. Anterior end of shell rounded or truncate. One specimen shows obscure traces of obsolescent, rounded plications at the anterior end. All other specimens observed have the surface smooth except for occasional ridges of growth.

Abundant in a single zone at Delphi.

### *Gypidula (Sieberella) galeatus* Dalman.

Pl. II, figs. 20, 21 and 23 to 29.

Shell ovoid or subglobose; valves unequal, the pedicel valve being much larger and more convex than the brachial. Pedicel valve uniformly rounded from the umbone to the front, the outline being nearly that of a segment of a circle; beak very gibbous and strongly incurved. Some specimens have an indistinct, broad fold at the front bearing four or five plications. In most individuals, however, there is little or no trace of a fold. Surface frequently marked with low, indistinct plications, which are obsolescent in the umbonal region. Fine concentric striæ are seen in perfectly preserved specimens. Many specimens show no trace of radiating plications. Very few brachial valves have been observed. These show a broad shallow sinus with three or four plications which are obsolescent posterior to the middle of the valve.

The specimens from Georgetown, which occur in a nearly pure limestone, greatly exceed in size those from other localities, which are all from dolomites. An average brachial valve from the

Georgetown locality measures in width 26 mm., length 27 mm. An average specimen from the dolomite measures in width 15 mm., length 16 mm. A brachial valve from the dolomite has the following dimensions—width 17 mm., length 12 mm.

The species occurs commonly as natural casts showing the single strong septum of the pedicel valve extending about one-third the distance to the front, and in the brachial valve two much finer septa in the umbonal region.

Hall and Clarke in the Pal. N. Y., Vol. VIII, have proposed to distinguish the Niagara Group forms of this species by the name *Gypidula* (*Sieberella*) *roemeri.* The specimens from the Glades in Perry County, Tenn., which have been made the types, are similar in all respects to the Georgetown material. However, no difference can be detected between these forms and the typical expression of Dalman's species, as the latter occurs in Europe and in well preserved specimens in the Lower Helderberg of New York. *G. roemeri,* which was never described, must therefore be considered only as a synonym of *G. galeata. G. nucleus* should also, perhaps, be referred to this species, as the Indiana material shows many gradations between the round plications of *G. galeata* and the more angular ones of *G. nucleus,* while some specimens are smooth. Prof. Whitfield informs us that the specific description of the latter species was drawn from the best specimen which happened to have angular plications, though many, if not most, of his specimens were either smooth or had rounded plications. The name "nucleus," therefore, can represent at most only a variety.

It is worthy of note that at Georgetown, where the only specimen of the type of *G. nucleus* was found, *G. galeata* is quite abundant and varied.

The species is common, occurring at Georgetown, Pendleton, Wabash, Fishersburg, and Little Deer Creek, Carroll County.

### *Gypidula* (*Sieberella*) *nucleus* Hall and Whitfield.

Pl. II, figs. 18, 19.

This "species," which is represented by a single pedicel valve from Georgetown, shows the following characters:

Valve ventricose and strongly arched; umbone inflated and beak incurved. Surface marked by seven angular plications

which become obsolescent in the umbonal region. The two strongest of these are slightly elevated to form a median fold.

### *Camarotoechia sp. undt.*

Pl. VIII, fig. 3.

A single brachial valve of an undetermined species appears in the collection from Little Deer Creek.

The valve is very gibbous, length three-quarters the width. Surface marked by twelve strong plications, four of which are elevated into a median fold.

Rare. Little Deer Creek, Carroll County.

### *Camarotoechia cf. acinus* Hall.

Pl. VIII, figs. 1, 2.

Casts of two or three brachial valves are doubtfully referred to this species. Surface with seven rather strong plications, two or three of which are elevated into a median fold which is not very prominent.

Rare. Pendleton.

### *Wilsonia saffordi* Hall.

Pl. VIII, figs. 4-9.

Shell very gibbous or subglobose; surface marked by from 20 to 36 plications which vary in strength according to their number; plications frequently marked by shallow median groove near the front. Fold and sinus not sharply defined, apparent only at the front and marked by 5 to 11 plications. Beak of pedicel valve acute, curved over the brachial valve.

This shell is comparatively rare. Found at Georgetown and at Bunker Hill.

### *Eatonia goodlandensis n. sp.*

Pl. VIII, figs. 10-12.

Shell subcircular, hinge line straight, equal to two-thirds the greatest width of the shell. Brachial valve ventricose, the gibbous umbone extending over the hinge line, while the beak is incurved closely against that of the pedicel valve. An indistinct fold is developed near the front. Pedicel valve moderately convex in the umbonal region, from which the slope to the margin is quite

regular. A deep, rounded sinus toward the front deflects a tongue-like projection of the valve into the front of the opposite valve nearly at right angles to the plane of the margin. A weak plication marks the bottom of the sinus; beak closely incurved against the beak of the brachial valve. Surface smooth except for the plication in the sinus and occasional lines of growth.

The species is known from a single specimen from a quarry one mile northwest of Goodland.

### *Atrypa calvini* Nettleroth.

Pl. VIII, figs. 13-15.

Shell small, brachial valve more convex than the other. In young specimens brachial valve is nearly flat. Ventral valve sloping gently from the convex umbonal region toward the lateral margins, near which it is abruptly deflected downwards, forming a concave zone inside the margin; beak prominent, pointed and slightly incurved. Sinus most prominent at the front, where its junction with the fold forms a high U-shaped loop. Two or three plications usually occupy the sinus. Dorsal valve with well developed fold toward the front usually bearing two plications; fold scarcely elevated above the adjacent parts of the shell. The plications of the fold are sometimes depressed below the general surface in the posterior portion of the shell, giving the appearance of a sinus. Surface of the shell marked by 15 to 20 strong, rounded plications, which increase by bifurcation and interstitial addition. No other surface markings visible.

This species is placed by Schuchert as a synonym of *A. rugosa* (Hall), but the specimens though showing the finer growth lines afford no trace of the strong, elevated lamellæ characterizing that species.

This is one of the most abundant and generally distributed species in the Niagara of Northern Indiana, occurring at Georgetown, Delphi, Logansport, Pendleton, and other localities.

### *Atrypa reticularis* Linnæus.

Pl. VIII, figs. 16-18.

Shell subcircular in outline. Valves moderately convex to gibbous; usually the two valves are about equally convex, but the brachial valve is sometimes much more convex than the ped-

icel valve. Pedicel valve frequently with a faintly defined sinus at the front; brachial valve sloping regularly to the front and sides. Surface marked with thirty-five to fifty fine, radiating plications which bifurcate freely in the posterior half of the shell. The largest specimen seen measures in length 20 mm., in width 19 mm. An average specimen has a length of 16 mm., width, 16 mm., and thickness, 11 mm. The most striking difference between the Niagara phase of this species and the form occurring in the Devonian limestones of Indiana is in the size, the latter being three or four times the size of the former; in the Devonian form, also, the brachial valve is usually much the more convex in contrast with the nearly equal convexity of the valves in the forms here described. The species is common at some localities. It occurs at Wabash (4A), and at Little Deer Creek, Carroll County.

### *Spirifer foggi* Nettleroth.

Pl. VIII, figs. 24, 25.

Outline of the shell as shown in the figure; ventral valve more convex than the pedicel; umbonal region gibbous, beak incurved. Fold and sinus prominent, with four to six, low, rounded plications on each side; entire surface covered with fine, thread-like striæ which dichotomize toward the front.

The largest specimen in the collection has the following dimensions: Width, 19 mm; length, 20mm; thickness, 13½ mm.

This species as suggested by Nettleroth is very closely allied to *Spirifer radiatus,* and it is doubtful whether it should be regarded as anything more than a variety of that species approaching the *Sp. niagarensis* type.

Known only from Georgetown, where four specimens were secured.

### *Spirifer nobilis* Barrande.

Pl. IX, figs. 1-5.

Shell transversely elliptical, valves moderately convex, cardinal extremities rounded; prominent fold and sinus, the former broad and simple, the latter without plications in the material examined. There are from four to eight strong, dichotomizing plications on each side of the fold and sinus. Entire surface covered by distinct, fine, radiating striæ.

The bifurcating and much stronger plications distinguish this form from *Sp. niagarensis.*

This is not a common species; from one to three specimens represent it in the collection from each of the following localities. Pendleton, Connor's Mill (Hamilton County), and Georgetown.

### *Spirifer radiatus* Sowerby.

Pl. VIII, figs. 19–23.

Shell rather large, rotund or robust; cardinal extremities rounded. Beak of the ventral valve incurved over the area, sinus broad and shallow; surface of the shell everywhere covered by fine, radiating striæ.

Two specimens of this shell from Georgetown show no trace of radiating plications, agreeing in this respect with the species as it occurs in the Waldron shale; all of the other specimens are marked by very low, rounded, radiating folds, of which there are four or five on each side of the fold and sinus. The latter type in some individuals approaches *Sp. niagarensis* closely in appearance.

The species is rather rare, occurring at Georgetown, Wabash, Connor's Mill (Hamilton County), and at Pendleton.

### *Spirifer (Reticularia) crispus var. simplex* Hall.

Pl. VIII, figs. 26, 27, 28.

Shell small, gibbous; ventral valve much more convex than the dorsal. There are two or three rounded plications on each side of the fold and sinus, the outer ones not reaching to the beaks; plications are crossed by fine lamellose, concentric striæ which have, fringing their margins, numerous very fine setæ; the latter characters are very well preserved in the natural moulds. Specimens from Waldron show them well developed. Ventral valve with thin, low, median septum extending about one-third the distance to the front. A thin dental plate, half the length of the septum lies on each side of it.

Comparatively rare, occurring at Georgetown, Pendleton, Little Deer Creek (Carroll County), and at Connor's Mill (Hamilton County).

### *Reticularia proxima n. sp.*

Pl. IX, figs, 6-8.

Shell transversely subovate; area short and low, partly concealed by the closely approximate beaks. Pedicel valve more convex than the brachial, marked by a distinct subangular sinus extending from beak to front. Brachial valve moderately convex in the posterior half. Slope very gentle to the front, but more abrupt to the hinge line. A mesial fold limited by a narrow but distinct depression extends from the umbone to the front; the fold is not elevated above the adjacent portion of the shell. Entire surface of shell marked by strong concentric lamellæ.

This species may be distinguished from *R. bicostata petilla* (Hall) by the lower area, and the absence of lateral plications or folds.

Rare. Represented by one specimen from Fishersburg, Hamilton County.

### *Reticularia sp.*

Pl. IX, fig, 9.

Two imperfect pedicel valves from Pendleton show the following characters: Strongly convex, sloping regularly to the front and sides; a very shallow sinus extends from the beak to the front; and a low, median septum extends about one third that distance; shorter dental plates on either side of the septum. Surface marked by fimbriate, concentric striæ; no plications or folds. The surface markings resemble those of *Spirifer crispus* as figured by Clarke and Ruedeman, Pl. IV, Memoir V, N. Y. State Mus.

Pendleton.

### *Cyrtia myrtia* Billings.

Pl. IX, figs. 10-12.

Shell pyramidal from front view; brachial valve semi-elliptical in outline. Pedicel valve with greatly elevated, slightly concave, triangular area, the beak inclined slightly backward over it. Surface sloping at an acute angle from the beak to the margin of the shell. A prominent rounded sinus extends from the beak to the front of the valve. Brachial valve gently and regularly convex. A low, rounded indistinct fold extends across the middle of the

valve. Surface of both valves covered with fine radiating striæ, of which there are eight or ten in the space of 1 mm.

Rare. Only two specimens seen, Georgetown and Delphi.

### *Whitfieldella nitida* Hall.

Pl. IX, figs. 13, 14.

Shell small; valves strongly and nearly equally convex; beak of pedicel valve acute and incurved. Surface smooth except for lines of growth. Front straight, slightly emarginate or rounded; faint sinus is present in emarginate specimens at the front of both valves.

Rare. Represented by five specimens from Georgetown and from Helm's Mill, Hamilton County.

### *Nucleospira pisiformis* Hall.

Pl. VIII, fig. 29.

The species is represented by poorly preserved casts showing the shallow sinus in each valve and the impressions of the low median septum of the pedicel valve extending nearly the entire length of the valve. Hall's description of the species as it occurs at Waldron is as follows:

"Shell lenticular, globose; valves nearly equal, each valve with a depression down the center. Ventral valve somewhat more convex, with the beak more elevated than in the dorsal valve. Area narrow, small, scarcely extending beyond the width of the beaks at their base. Surface marked by fine concentric striæ usually obscured by the covering of minute hair-like spines, which, when removed, leave a punctate surface."

Rare. Pendleton, and at Connor's Mill, Hamilton County.

### *Anoplotheca congregata n. sp.*

Pl. IX, figs. 18-20.

Shell small, subcircular and plano-convex. Pedicel valve very convex, beak incurved and extending slightly beyond the brachial valve. Two strong plications with a third intermediate somewhat weaker one form a prominent median fold, extending from beak to front. Three or four plications appear on each side of the fold. Interior of pedicel valve with transverse tooth on each side anterior to the area. A strong median septum extends one half to three quarters the distance to the front. Sides of brachial valve flat, with deep median sinus widening from the beak to the front.

From one to three indistinct plications occupy the sinus; surface on either side marked by three or four plications.

This species is abundant at one point in Logansport. The only species observed associated with it is a *Chonetes*. The species apparently does not belong to the Niagara fauna and is probobly a representative of the "Waterlime" fauna.

### *Meristina maria* Hall.

Pl. IX, figs. 29-32.

Shell large, outline as shown in figure. Valves about equally convex. Pedicel valve with incurved beak, gibbous in the umbonal region, becoming deeply sinuate toward the front and deflected upward in a linuiform extension. Interior of the valve with a deep, triangular-shaped muscular impression. Brachial valve convex in the umbonal region, sloping abruptly to the cardinal and lateral margins of the shell. A subangular or rounded ridge extends from the umbo to the front. Interior with a low septum extending one-third the distance from the beak to the front. Surface apparently smooth.

Common, occurring at Fishersburg, Georgetown, Pendleton and Connor's Mill, Hamilton County.

### *Meristina rectirostris* Hall.

Pl. IX, figs. 21-24.

Shell broadly ovate, margin nearly straight from the beaks one-third the distance to the front; thence regularly rounded to the front. Valves about equally convex. Pedicel valve sloping regularly to the sides from a median line of maximum elevation. Beak acute, nearly straight, and projecting beyond the opposite valve; area triangular. Brachial valve regularly convex; beak small and closely incurved. No surface markings preserved.

Rare. Known only from Little Deer Creek, Carroll County.

### *Maristina cf. princeps* Hall.

Pl. IX, fig. 25.

A single brachial valve has been seen which probably belongs to this species. It differs from *M. maria* in having the surface marked with distinct radiating striæ toward the front and lateral margin.

Rare. Georgetown.

## PELECYPODA.*

### *Tellinomya cf. nasuta* Hall.

Pl. X, fig. 1.

A single specimen found east of Kentland has the following characters:

Shell transverse, length twice the height. Beak a little anterior to the center. Upper margin extending forward in a direction parallel to the transverse axis, thence continuing in a broad curve extending downward to a point in front of the middle of the ventral margin; thence deflecting upward in a broad, shallow, undefined sinus. Posterior end half the height of the anterior end, sharply rounded, nasute; superior margin straight or barely arcuate to the umbo, deflected a little upward. The beaks are broadly obtuse, incurved, slightly directed forward, and extending very little beyond the hinge. The most convex portion of the shell is just back of the anterior muscular scar. In front of the posterior scar is a somewhat flattened shelf or platform. The pallial line is fimbriate, entire, and does not partake of even the very shallow sinus of the ventral margin. The muscular scars are large, deeply impressed in the shell, with a distinctly elevated rim except at the distal ends, and with their major axes in the respective lines running from the middle of the beak to the center of the anterior margin, and from the beak to the posterior margin. The anterior muscular scar is seven-eighths as high as long, close to the superior margin, and two-fifths in length the distance from the beak to the middle of the anterior margin. Posterior scar in similar relative position, but narrower, with the length more than twice the height and equal to two-fifths the distance from the beak to the middle of the posterior margin. The anterior and posterior limits of the muscular scars undefined. Each of the scars is a little nearer the anterior or posterior margin respectively than to the beak. There are no umbonal scars, nor accessory retractile scars, nor can the dentition be seen. This shell evidently belongs to the typical group of *Tellinomya* as represented by the *T. nasuta* from the Trenton limestone. A shell very similar in outline, the *Nucula hanoverensis* of Kindle is found in the Devonian lime-

*For references to the original descriptions of the species of this and succeeding groups, see Miller's North American Geology and Paleontology.

stones, but the latter represents a species which generically is very distinct. About the only difference which can be detected between our species and *T. nasuta* as found in the Trenton of Wisconsin is that in the former the posterior end is just perceptibly narrower than in the Wisconsin forms.

The single specimen described above is a left valve and its cast from Kentland (1C1). The inside surface of the shell is smooth as is also the cast. The height of the shell at the posterior end of the anterior scar is 23 mm. The transverse axis passing just below the scars is 49 mm., and the valve is about 4 mm. thick.

### *Whitella (?) siluriana n. sp.*

Pl. X, fig. 15.

Shell small, quadrate, rhomboid, length and height about equal. Hinge line straight, three-fourths the length of the shell, and forming at an angle of about 130 degrees with the upper part of the posterior margin. The last named is arcuate to the gonial angle which is broadly rounded. Basal margin straight or nearly so; abruptly curved at a right angle into the short vertical anterior margin. Beaks consisting only of the upper end of the gonial ridge, incurved, protruding, depressed to the plane of the margin. Gonial ridge very prominent, hardly arcuate, becoming less well defined posteriorly. Point of greatest convexity of the shell on the ridge, just above the middle. Cast smooth.

Only a single right valve which is the type of the species is known. Length, 6½ mm., height, 5½ mm., thickness, 2½ mm. It is referred to *Whitella* with some hesitancy. There is a striated external ligament, and a very pronounced linear posterior elevation which seems to be a well developed tooth rather than the platform of an internal ligament as Ulrich considers a somewhat similar feature in Ordovician typical forms of the genus. The form is somewhat like Hall's *Cypricardites (?) quadrilatera,* but our species is higher, with the superior and ventral sides parallel, and has a rather different hinge structure. There is some resemblance to *W truncata* (Ulrich) but that is a much more gibbous shell.

One specimen, Wabash.

### *Cypricardinia sp.*

Pl. X, fig. 14.

A single external mould of a left valve from Pendleton has the following characters:

Shell small, rhomboidal; anterior end small, ventral margin formed by two subequal, slightly arcuate lines extending from the antero-ventral and postero-ventral margins and meeting in a broad angle; posterior margin, abruptly truncated, forming an angle of 135 degrees with the hinge. There is a slight retral curve to the posterior margin which produces an alation and gives the shell an aviculoid appearance. Hinge line unknown but apparently straight. The markings consist of concentric folds which have a slight but very distinct sinus at the anterior fifth and another sinus corresponding to the alation of the posterior margiu. The folds are small and at the anterior portion of the shell are close together; but from just back of the sinus to the gonial ridge these folds are very strong, becoming obsolescent on the posterior slope. There are faint traces of fine concentric striæ.

This shell has the outline of the *Clidophorus* (*?*) *mc. chesneyanus* of Winchell and Marcy, which is now considered a *Colpomya* but which Miller believed to have been identical with the *Modiolopsis rectus* of Hall. The first named species differs from that described above in the absence of the strong folds and also of the posterior alation.

Our specimen from Pendleton has a length of 15 mm., and height of 8 mm.

### *Pterinea sp. undet.*

Pl. X, fig. 8.

In the subcentral position of the beaks there is a resemblance to the *Pterinea curiosa* of Billings. The beak of the left valve of the Indiana species is not protruded beyond the hinge line, nor is it elevated. The casts are smooth with no markings whatever.

Of the two specimens found, the larger which is figured is from Delphi (2/A1), and the smaller one from Wabash (4/A2).

### *Amphicoelia neglectu* McChesney.

Pl. X, fig. 10.

A large left valve belonging to this species shows the following characters:

Shell large, gibbous; approximate length, 72 mm., height 56 mm., thickness 18 mm. Beaks anterior, ventricose, incurved, pointed forward. Most convex point on the shell at upper and anterior third. Cast marked by fine striæ, of which there are twenty in 16 mm., at a distance of 50 mm. below the beak. These striæ are very low on the cast, though distinctly visible; more prominent in front. Towards the umbones and posteriorly, they become obsolescent, while below the hinge the cast is smooth. The hinge line is nearly equal to the length of the shell.

One specimen, Wabash.

### *Paleopinna sp. undet.*

Pl. X, fig. 13.

A fragment from Wabash (4/A2), is figured on Pl. X, Fig. 13. The hinge line is long and straight. The beak is anterior. The umbonal region is gibbous with an undefined post cardinal cincture or sinus. Shell thin, covered with radiate striæ and concentric growth lines. The latter are sharply elevated and are stronger than the radial striæ, which increase by implantation.

### *Conocardium multistriatum n. sp*

Pl. X, fig. 4.

Shell smaller than *C. oweni,* the only specimen found having an approximate height of 8 mm., length 9 mm. and thickness 6 mm. The anterior truncation is obsolescent, being represented merely by a slight deflection of the surface and the cessation of the surface markings. The latter consist of about twenty-seven fine striæ which are flat-topped in the casts but angular on the surface. The interspaces in the casts are fine impressed lines. The posterior striation is greatly enlarged and serves to demarcate the posterior portion of the shell which forms an angle of about 50 degrees. This posterior portion is covered by about eleven striæ or plications, which are very faint near the strong rib, but increase quite rapidly in size and strength as the posterior tube is approached.

The concentric markings consist of very fine, close-set rugose striæ, which are most prominent on the umbones and on the posterior portion of the shell. There are also two or three secular growth lines.

This species may be recognized by the fine surface markings.

The single specimen described above was found at Georgetown.

### *Conocardium oweni n. sp.*

Pl. X, figs. 2, 3.

Shell small, gibbous, the type specimen being 11 mm. long, 8 mm. high, and 6½ mm. thick. Anterior end abruptly truncated. Anterior margin beginning a little below the front end of the hinge line, and at an angle of about 100 degrees thereto, extending in a very slightly concave line to the base of the truncation which is the most anterior point in the shell. From this point, the ventral margin rounds strongly to near the middle, where it is gradually deflected in a broad curve up to the posterior opening. Hinge line straight. Beaks prominent, extending little beyond the hinge, and directed slightly backward. Greatest convexity of the shell one-third the distance from the beak to the base, and just behind the truncation. The front of the shell down to the top of the anterior edge is drawn out into an apparently broad but very short tube or opening.

The surface is marked by radiating, narrow plications crossed by lines of growth which become lamellose on the post-cardinal slope. There are two or three rounded plications on the truncate end near the upper edge, but these become obsolescent toward the umbones and toward the front, so that the base of the foward one is at the middle of the anterior edge. The interspaces are indistinct and are crossed by very faint lines of growth which become stronger near the anterior tube. From the edge of the truncation to the posterior tube, the surface is covered by about 18 low, rounded plications. These are most sharply defined on the more convex portions of the shell, where they are nearly flat-topped and with smooth interspaces about equal in width to, or perhaps a trifle wider than, the plications. Posteriorly the plications are a little sharper, but the interspaces and the plications too, are rather less developed than in front. Simultaneously with the obsolescence of

the interspaces, the growth lines begin to develop quite strongly. These are hardly perceptible on the convex portion of the shell, but beginning at the post-cardinal slope they become lamellose so that at the base of the posterior tube, they are nearly as strong as the radiate markings. These lamellæ when well preserved cross the ridges of the plications and produce a minutely crenulated effect, but usually they are preserved only in the interspaces, where they show a rather cancellate structure. The surface of the posterior tube is smooth except for faint growth lines. No secular growth lines have been observed.

This species is very closely allied to and perhaps identical with the *Pleurorhynchus antiqua* of D. D. Owen (Rep. Geol. Reconnaissance of Wis., Minnesota and Iowa, 1852, Pl. 2B, Fig. 19). Owen's species is very poorly figured, not at all described, and even the locality at which it was found is omitted. Poor as his figure is, there is, however, a rather close resemblance to our species. There is also a close resemblance to *C. niagarense* of Winchell and Marcy; but the lamellose lines of growth characterizing our species are not recognized in *C. niagarensis,* nor does the figure of the Chicago species (nor the description) show the anterior end partially plicate as is the case in our species.

The type specimen and another fragment were found at Little Deer Creek, while a third fragment of a specimen similar to the above was observed from Connor's Mill, Hamilton County. The last named must have been at least 15 mm. long when entire.

***Plethomytilus cuneatus n. sp.***

Pl. X, fig. 9.

Shell mytiloid, height about one and a half times the width. Greatest width two-fifths the distance from the base up. Anterior margin approximately straight, rounding off basally and posteriorly. Beaks gibbous, acuminate, protruding beyond the hinge, not twisted nor laterally bent. The point of greatest convexity is in the anterior portion and one-third the height from the umbonès. Anterior slope perpendicular to the plane of the margin. Posterior slope very steep at the umbones, but becoming less so at the base. Muscular scar (?) ventro-posterior. Ligamental area with one or two striations posteriorly.

This species is much wider than *Mytilarca acutirostra* Hall's sp. The beak is more acuminate than in his *Ambonychia aphea,* and is not twisted as it is in that species. From the *Mytilarca sigilla* (which is probably an Ambonychia) our species differs in the absence of the posterior alation.

A single left valve was found at Georgetown (3/A1). It has the following dimensions: Height, 32 mm.; width, 22 mm.; thickness, 8 mm.

### *Streptomytilus n. g.*

Shells mytiloid, erect, beaks twisted toward the front, acuminate, protruding beyond the hinge line. Surface markings concentric growth lines. Hinge furnished with a posterior ligamental groove. There is an internal linear platform or septum as in *Mytilus edulis* to which the ligament is attached. This platform is present as a groove in the cast. There are no teeth nor are there any ligamental striations. Type, *S. wabashensis n. sp.*

*Ambonychia aphea* (Hall) and the *Mytilarca eduliformis* (Conrad) and of Clarke and Ruedeman should also be included in this genus.

### *Streptomytilus wabashensis n. sp.*

Pl. X, figs. 11, 12.

Shell small mytiliform, erect, height less than one and a half times the width. Anterior margin straight from the hinge half way to the base, thence curving in an arc of 240 degrees to half way up the posterior side, and continuing in an arcuate line to the umbonal hinge, which is rather obtusely rounded. Beaks terminal, gibbous, twisted to the front, protruding beyond the hinge lines, and depressed to its plane. Greatest convexity of the shell one-third the distance from tip of beak to the base. Anterior and posterior slopes about equal. Shell thin. Surface markings faint, concentric growth lines.

Only a left valve of this species is known. It was found at Wabash, and has a height of 13 mm., width 9½ mm., thickness 3 mm. It is, however, so distinct as to fully warrant its generic separation from the known forms of lamellibranchs. It differs from *Plethomytilus,* its nearest Paleozoic ally in the absence of a

straight hinge line, of lateral teeth, and of the striations on the ligamental groove. From the recent forms of Mytilus, it may be distinguished by its more protruding and twisted umbones.

### *Anodontopsis wabashensis n. sp.*

Pl. X, figs. 5-7.

Shell small to medium sized, rhomboidal to trapezoidal in outline; length twice the thickness and one-fourth greater than the height. Margin rapidly rounded in front, broadly rounded ventrally to the posterior two-thirds; thence curving upward to the postero-ventral angle, where there is a more or less abrupt and oblique truncation at an angle of about 120 degrees to the hinge. The last named is straight and half the length of the shell. Beaks in the anterior sixth, quite prominent, pointed forward, and extending very little beyond the hinge line. Point of greatest convexity posterior and superior to the center. Post cardinal slope steep and slightly concave. Surface markings faint concentric growth lines. The hinge characters are preserved in only one large specimen which shows fairly long, linear tooth. Anterior portion of the hinge unknown.

The type specimen is 20 mm. long, 16 mm. high, and has a thickness of 5 mm. (one valve).

The species may be recognized by the short hinge line and character of the surface markings.

Six valves of this species all of nearly the same size were found at Wabash (4/A2 and 4/A4) in a few hours' collecting.

## GASTEROPODA.

### *Platyceras* (*Diaphorostoma*) *cornutum* Hisinger.

Pl. XIII, figs. 9-16.

In the dolomitic limestones of northern Indiana several localities have shown the presence of this species. The specimens from Little Deer Creek, Pendleton, Georgetown, and Wabash bear but little resemblance to the spire-bearing forms from Waldron, but show a great affinity to Roemer's Tennessee specimens, and especially to that phase of the species described from Chicago by Winchell and Marcy as *Platyceras campanulatum*.

The spire is depressed, with the apex more or less below the plane of the upper side of the body whorl. The initial one or two

volutions are minute, but there is a sudden expansion and increase in the size of the body whorl. The body whorl is partially free. The aperture, where preserved, is flaring and the peristome is reflexed like the end of a trumpet. The surface markings are usually almost imperceptible lines of growth. A large Georgetown specimen shows about fifteen fine, revolving lines on the volution next to the body whorl, while the latter exhibits only very lamellose ridges of growth increasing in number as the peristome is approached.

At Connor's Mill, Hamilton County, from the dolomitic limestones of which place more specimens of the species have been obtained than from anywhere else in northern Indiana, there is in the general aspect great difference from the forms described above. All the seven specimens obtained from here show a remarkable uniformity of characteristics. The spire is elevated, consisting of three regularly-rounded and contiguous whorls, increasing gradually in size from the apex to the mouth. The length of the spire is two-thirds the greatest width of the body whorl. The surface is marked by nine or ten low, rounded, revolving bands which disappear on the upper side near the suture and are crossed by almost imperceptible lines of growth. The apertural characters are unknown, but the peristome was evidently not reflexed. It is possible that the remarkable uniformity of the Connor's Mill material, and its persistent differences from the forms of *Platyceras cornutum* occurring in the surrounding portions of northern Indiana, may be sufficient cause for the separation of the former specimens from that species.

The forms referred to this species have a world-wide distribution, occurring in Bohemia, the Hartz, France, England, Wales, Scotland, Ireland, Canada, and the United States. In England the species has also a great vertical distribution; but on this continent, where it has been recorded from New York, Canada West, Michigan, Wisconsin, Illinois, Indiana, Ohio, Pennsylvania, Kentucky, and Tennessee, it is confined to the beds of the Niagara Group (including the Guelph dolomites). The species occurs in great abundance in the Rochester shale of New York, and at Waldron, Indiana.

Known from Carroll County, Pendleton, Connor's Mill, and Georgetown.

### *Bucania sp. undet.*

Pl. XI, fig. 3.

A fragment of a Buchania similar to those figured in Vol. II, Pal. N. Y., Pl. 76, Figs. 5, 6, was found at Georgetown.

### *Pleurotomaria* (?) *idia* Hall.

Pl. XII, fig. 6.

Spire depressed convex. Width of the shell two or more times the greatest height. Volutions three or four, very gradually increasing in size; not marked in the casts by any peripheral band or keels. Umbilicus broad and open.

A large cast referred to this species has a height of 45 mm., and width of 21 mm., and there are apparently only three or three and a half whorls. In all other respects it is like the typical forms described from Racine, Wisconsin.

Rare. Huntington.

### *Pleurotomaria laphami* Whitfield.

Pl. XI, fig. 4.

Spire conical, moderately elevated, apical angle about ninety degrees or less. Volutions three to three and one-half, subtriangular, flattened exteriorly in the direction of the apical angle, subangular in the periphery and rounded below; suture distinct in cast, indistinct on surface of shell; umbilicus large. Surface of shell smooth or marked only by striæ of growth.

The above description is drawn mainly from Whitfield. The species is occasionally seen in the form of casts at Delphi.

### *Pleurotomaria hoyi* Hall.

20th Rep. N. Y. State Cab. Nat. Hist., 1867, p. 364, pl. 15, fig. 10.

"Shell broadly depressed—conical. The spire moderately elevated, consisting of about four volutions, which are gradually enlarged from the apex, the last one being slightly ventricose toward the aperture. Volutions flattened on the upper side, and the entire height of each one showing above the other; periphery somewhat flattened, with a depressed band truncating the upper angle. Lower side of volutions flattened, except the outer half of the last one, which is rounded toward the aperture and abruptly descending into the wide umbilicus.

"Surface finely striated on the lower side of the volution, with a deep retral curve on the band, where the striæ are somewhat fasciculate. The periphery of the cast is sometimes marked by three or four strong, but obscure striæ below and parallel to the revolving band."

The above description by Hall is based upon much better material than the collection at hand affords.

This species is represented by casts from Delphi.

### *Pleurotomaria pauper* Hall.

Pl. XII, figs. 5, 6.

"Shell small, depressed conical, the apical angle being about seventy or seventy-five degrees; volutions three or four rounded and somewhat rapidly increasing in size from the apex; the aperture has been a little longer than wide. The specimens occur in the condition of casts, which preserve the evidence of a spiral band a little above the middle of the volution, and between this and the suture line there is a slightly elevated line or carina.

"The surface of shell is unknown."

The above is the original description of the species (20th Rep. N. Y. State Mus., p. 343).

Casts and moulds of this species occur in the quarries at Huntington.

### *Pleurotomaria sp. undet.*

A single quite remarkable fragment belonging to a probably undescribed group of the *Pleurotomarias* has the following characters (only the body whorl is preserved):

Width of body 35 mm., height 18 mm. Whorls subcircular in section, columella solid, narrow; umbilicus quite wide but shallow. Slit-band prominent, vertical, elevated at the periphery, slightly concave. About midway between the band and the suture there is a strong raised line, which is one-third as wide as the slit-band. Between this line and the suture the surface is marked by strong, rounded, transverse undulations. From the line to the slit-band, the surface is smooth except for faint traces near the line of the undulations. The surface markings are faint lines of growth which follow the undulations. Above the slit-band, where the undulations die out, the striæ swing back at an angle of between forty

and sixty degrees. There are apparently no other revolving markings. In the markings above the slit-band, this species is remarkably similar to the *Pleur. dolium* of Lindstrom, but is decidedly distinct in all other respects. There is also a resemblance in the presence of a sort of revolving line between the band and the suture to some of the forms referred by Clarke and Ruedeman to *Lophospira.*

One specimen. Old Deer Creek channel (2A3), Delphi.

### *Pleurotomaria* (?) *axion* Hall.

Pl. XII, fig. 4.

Shell subconical, volutions about four, contiguous, the upper ones increasing gradually in size; the body whorl is greatly enlarged. Suture nearly transverse, deeply impressed with more than half the preceding volution* exposed above it. Whorls rounded to ventricose, nowhere flattened nor sharply angular.

Mouth very large, about half the length of the shell. Inner lip long, directly anteriorly, slightly recurved. Slit-band at the middle of the body whorl, but in the upper whorls a little more than its width above the suture. In the Bridgeport, Ill., specimens, there are, according to Hall, "strong revolving striæ which are crossed by concentric striæ of less strength giving a cancellated structure." The aperture is not preserved in the Illinois specimens so that its description is drawn from the Huntington specimen. This is an external mould which, with the exception of the faintly-preserved carina, shows no surface markings. Its height is 48 mm., width, 28 mm.

There is a rather close resemblance to the variable European *Pl. lloydii,* but the inner lip of the American species is much longer and recurved.** In our form also, it cannot be determined whether this recurved cylindrical lip is hollow (a canal), or solid.

Rare. Huntington.

### *Pleurotomaria eloroidea n. sp.*

Pl. XIII, figs. 1, 2.

Shell subconical, medium sized. Whorls contiguous, about four in number. Sutures not deeply impressed, and nearly

*Exclusive of the prolongation of the inner lip.

**The direction of this "recurvature" is the opposite to that ordinarily met with; that is, the inner lip is concave in a view into the aperture.

transverse. Whorls depressed above, broadly rounding off down to the peripheral band; outline slightly concave just above the concave (?) slit-band. The lower border of the slit-band is developed into a rim or flange, the inner edge of which forms the suture. Surface or character of the volution below the slit-band unknown. The markings consist of strong lines of growth and revolving lines. The former begin quite transversely from the suture, but after extending in this direction two-fifths the distance to the keel, they swing back in a broad curve, become almost parallel to the slit-band for a short distance and just above it, and then develop slight lunulæ on the band. By the unequal crowding of these lines of growth, the surface is thrown into very low, indistinct folds. The revolving lines are very fine, and nearly a millimeter apart.

Known from a single specimen which has a width of 50 mm., height from apex to flange, 18 mm., half of this partial height being in the body whorl.

There is a very close resemblance in the outline and rim of this species and that present in the genus *Euomphalopterus,* but an examination of the characters described above will reveal the fact that not even a generic identity can exist between the two. The broad backward swing of the striæ above the slit-band and their direction parallel to the latter just above the band, show the presence of a very deep notch and of a slit (?) not found in *Euomphalopterus.* The flange also is a free extension of each border of the slit-band (see Pl. XIV sp. *cf. eloroidea*) so that the similarity between *Pleurotomaria eloidea* and *Euomphalopterus* is wholly superficial. There is no sigmoid curve to the striæ and the flange does not rest on the lower whorls as it does in *Euomphalopterus,* but these are minor characters.

A generic comparison may perhaps be made with *Mourlonia,* but the extension of the flange along the suture in our species at once distinguishes it from that genus in which the flange is exposed near the middle of all the whorls.

There is some resemblance in outline between our species and the *Pleurotomaria elora* of Billings.

Rare. Delphi.

### *Pleurotomaria cf. eloroidea.*

Pl. XIV, fig. 3.

Shell very large, resembling the preceding in outline and in surface markings.

The slit-band in the form now described is very plainly convex. It is bordered on both sides by diverging curved flanges. The lunulæ are shallow and evenly convex. The striæ of growth in the upper portion of the whorl swing back, and this backward swing is continued across the slit-band and lunulæ.

The characters described show a close similarity to *Mourlonia,* from which our shell differs in having plain crescents, and the flanges disposed along the suture. It occupies an extremely important position which can not be overlooked between *Euomphalopeterus* and *Mourlonia,* and forming a phylogenetic series with those two in the order named. A recurving of the upper face of the flange would be almost all that would be required to develop from *Euomphalopterus* the form represented by our species. The development of the whorls so that the flanges would be on the periphery instead of on the suture would generate a form which would very easily pass off into the *Mourlonia limata* type by the chronogenetic addition of the lobe to the crescent.

Rare. Huntington.

### *Euomphalopterus alatus var. americanus n. var.*

Pl. XIII, fig. 6.

Shells small depressed conical, consisting of three to four very gradually increasing and contiguous whorls. The volutions are subcircular in cross-section; horizontally flattened or depressed convex near the suture, sharply rounded at the sides, and rounding off into the umbilicus. The latter is very wide and included in a broad columella which is as wide at the base as the cross-section of the body whorl. At the middle of the periphery is a very sharp and projecting carina or rim, somewhat similar in character to that in the *Murchisonia worthenana* of Miller, and especially to the forms of *Pleur. alata* from Gotland. The surface is covered with close-set, transverse lines which arch very strongly forward over the rim or flange. Some of the striæ dichotomize on both faces of this flange. There is an obscure line or ridge concentric with, and near to, the inner edge of the flange.

The suture between the whorls is along the bottom face of the rim, which, when flattened over the upper portions of the younger whorls, presents a false appearance of a shoulder. Apertural characters unknown. The rim extends all along the suture, and may be traced almost to the initial whorls. The striæ as exposed on the upper face of the rim along the sutures, are straight and pointed forward.

Two specimens have respectively the following dimensions: Width, 10 mm. and 6 mm.; height (approximate), 5 mm. and 3 mm.

This shell belongs to the group of the *Pleurotomarias* designated by Roemer in 1876, *Euomphalopterus,* with *E.* (*Pleur.*) *alatus* as the type. It includes *Pleurotomaria alata, pretexta, togata, frenata, undulans, marklini,* and among American forms the *E. alatus* of Ulrich, which was recently (1897) described by that author as coming from near Waldron, Ind. The group is characterized by the expansion of the "slit-band" into a rim or flange which extends along the suture line. There is no slit, and in most of the typical forms the striæ are directed forward to the rim. There are no revolving bands and only rarely faint revolving markings. This is perhaps the most strongly marked and easily separated group of the *Pleurotomarias.*

The variety described above is very close to Lindström's variety *opposita,* but the American form is a much smaller shell with lower spire and fewer whorls, and with the striæ when dividing, bifurcating instead of being divided into a brush as in the Gotland variety. From Ulrich's variety and also from true forms of *Euomphalopterus,* the variety described above differs in having the band situated at the middle of the periphery and having the whorls regularly rounded.

Though apparently widespread and abundant in Europe, *Euomphalopterus* is quite rare on this continent, where Ulrich's variety has been the only representative known up to date. A closely allied form is the *Murchisonia worthenana* of Miller, which is probably equivalent to *Pleurotomaria* (*Mourlonia*) *limata* of Lindström, though Miller's name has priority. In *Mourlonia* the striæ always curve backward to the band, there is a true slit-band, while the rim, instead of extending along the suture as in *Euomphalopterus,* is exposed some distance above the suture near the periphery

of the upper whorls. There are also some minor differences which will be noticed later.

Rare. Little Deer Creek, Carroll County.

### *Euomphalopterus alatus var.*

A single specimen of a third variety of this species resembles a large form of the variety *americanus;* but is discoidal, almost plane-coiled. The flange along the suture is the only important character observed. It has not the smaller line or ridge near the inner edge possessed by the variety *americanus,* and the striæ on the flange are almost straight, pointed forward, and crenulated by very fine, faint, revolving lines, which are barely visible under a strong magnifying glass.

Rare. Georgetown.

### *Euomphalopterus alatus var. limatoidea n. var.*

Pl. XIV, fig. 4.

Shell very large, depressed turbinate. Whorls four or five or more, contiguous, flattened above by the sutural band, turned in a broad curve downward, slightly concave just above the flange, and continuing below the latter in a nearly horizontal plane, curving upward toward the middle. The flange is therefore on the lower margin of the periphery, and may almost be said to bound the umbilicus. The umbilicus is very broad. The surface is marked by striæ arching forward to the flange, and also by revolving lines.

A single, large specimen, belonging to the Indiana State Museum, has an approximate height of 36 mm., and a width of 70 mm. The body whorl is 23 mm. high.

This form, as the name is intended to signify, is intermediate between *E. alatus* and *Pleur.* (*Mourlonia*) *limata.* It is larger than either, and has a greater umbilicus and lower spire. Its markings are very distinctive. It should more probably be made a separate species.

Rare. Delphi.

### *Murchisonia* (*Turritoma*) *laphami* Hall.

Pl. XIII, fig. 7.

Shell rather large, turreted, height several times the width. Volutions contiguous, seven or eight in number, and increasing gradually in size. Sutures close and oblique. Sides straight or

flat, sloping from the suture to the slitband, which is concave, but becomes almost flat on the body whorl, where its height is one-sixth the height of the whorl. The lower portion of the volution is ventricose. The band is in the center of the body whorl, but in the upper whorls it is half its height above the suture.

Owing to the unnatural and improper divisions which have been formed from Murchisonia, it is preferred in this paper to regard all the species thereof as species of the original genus.

Several casts and moulds of this species have been obtained at Huntington. One mould of the three lower whorls showed a height of 44 mm., width 23 mm., height of body whorl 22 mm. The outline, etc., seem to be the same as in typical forms of M. laphami, but the slit-band of the Huntington specimens is rather wider than that of the Wisconsin material.

### *Murchisonia* (*Coelacaulis*) *bivittata* Hall.

Pl. XIII, fig. 4.

Shell very elongated, consisting of about twelve rounded volutions without trace of carina, but with a strong biplicate columella.

The plicate columella and the absence of the dorsal band are characters which should remove this species from the *Murchisonia* group.

A large internal cast referred to this species was found at Huntington by Mr. Gilbert. There are six of the lower plications exposed, showing a height of 50 mm., a width at the base of 29 mm., and at the summit of 14 mm. There are obscure traces of revolving lines on the surface and of a plicate columella in the highest whorl.

Rare. Huntington.

### *Murchisonia sp. undet.*

Fragments of a very large species of Murchisonia are quite common at Huntington. The specimens are larger and differ from any of the species of that genus hitherto described from the Silurian. An idea of the size may be obtained when it is stated that a cast of the body whorl and one upper whorl has a height of at least 54 mm. The whorl above the body whorl has an exposed height of 18 mm. There are several specimens quite as large as the one mentioned. The uppermost portion from the suture down

to the shoulder, is flat, or perhaps a trifle concave. From the shoulder the sides extend straight downward, making with the upper, flattish portion an angle (in profile) of about 135 degrees. The base of the whorl is broadly rounded. A section of the body whorl is subhexagonal, higher than wide, with the suture at the upper angle. In the upper whorls only the flat, sloping portion from the suture to the shoulder and the vertical sides are exposed. There is a general resemblance in the contour of the whorls to those of *Trochonema fatuum* Hall, but our form is evidently a turreted Murchisonia, much larger in size, and the vertical sides in Hall's species are smaller than in ours.

Two or three other species of large *Murchisonias* occur at Huntington, but they are unidentifiable. It is an interesting fact that no species of this genus have hitherto been recorded from the Silurian of Indiana.

Common. Huntington.

### *Oriostoma huntingtonensis n. sp.*

Pl. XIV, figs. 14, 15.

Shell turbinate, fairly large, consisting of three or more rounded volutions which are circular in cross-section and increase gradually in size. The whorls are contiguous, and each shows almost its entirety above the others. Shell substance thick and composed of at least three layers. The outer one is marked by strong revolving ribs with the interspaces concave and about equal to the ribs in width. The umbilicus is large and open, and is bounded by a very strong keel, which is stronger than any of the other keels on the surface. With the exception of traces of another keel in further in the umbilicus, the only markings observed in the latter are faint revolving striæ. The finer surface markings are but poorly preserved, and the test is found only on the lower half of the body whorl of the type specimen. This shows ten ribs in 17 mm. from the umbilicus to the middle of the periphery. Aperture unknown.

The specimens have the following dimensions:

| | *Height.* | *Height of Body Whorl.* | *Width.* |
|---|---|---|---|
| Type | 35 mm. | 24 mm. | 43 mm. |
| Second | 36 mm. | 25 mm. | 46 mm. |
| Third | 36 mm. | 23 mm. | 45 mm. |

This species is closely related to the forms of *O. macrolineatum* as found in the Guelph limestone at Elora and Durham, C. W., and also to *Poleumita scamnata* of Clarke and Ruedeman, but the Indiana forms are distinct. The specimens found at Huntington show much stronger and more closely-set ribs, while the remarkable keel bounding the umbilicus is a feature never seen in any of the others, in which respect our forms are very close to the Gotland species described by Lindström.

Rare. Huntington.

### *Oriostoma* (?) *opercula.*

Pl. XIV, figs. 10-13; Pl. XI, fig. 6.

Opercula referred to this genus have been found at Huntington by Mr. Gilbert, who, after a search of several years, has brought to light four of these specimens. They are all low cones. The apical region (the nucleus) is nearly smooth, but beginning a short distance from the center are eight to thirteen nearly lamellose coils, the number varying with the individual. The marginal characters are indistinct, but there seems to have been a low cylindrical extension rather than a flat band.

A natural mould at hand shows the characters of both the exterior and interior surfaces of the operculum, the specimen preserving about five-sixths of the latter and one-fifth of the former. The outer half of the interior surface is nearly flat and surrounded by a wide rim. From nearly flat the surface changes to moderately concave toward the center, a small circular, rather shallow pit appearing at the center. The interior surface is smooth except for a slight depression and groove on one side, which may not be structural features.

Following is a short tabular account of their characters:

| *Specimen.* | *Width.* | *Coils.* |
|---|---|---|
| 1 | 22 mm | 7¾ |
| 2 | 23 mm | 9 |
| 3 | 29 mm | 13 |
| 4 | 23 mm | 11½ |

The specimens may doubtless be referred to *H. huntingtonense.* The size of the mouth in the known specimens of that species corresponds very well with the size of numbers 1 and 2. Both the opercula and the type of *P. huntingtonense* were found in the same quarry.

*Oriostoma huntingtonensis var. alternatum n. var.*

Pl. XIV, fig. 9.

This differs from the above in the surface markings and in being a little more depressed. The markings from the umbilicus to the suture consist of eight or nine rather more distant ribs than are met with in the typical forms of the species, while between each pair of these ribs is a fainter one. The stronger keels are equal in strength, but the fainter, alternating ones, are obsolescent near the suture, and gradually increase in strength, descending toward the umbilicus until the lowest one is quite equal to the strongest keels. The umbilicus is wide and open, and is marked by faint revolving striæ and by a sharper keel near the middle.

Two specimens, preserving only the body whorl and part of the upper. Both show a width of the former of 34 mm., and a height of 17 mm. Both were found at Huntington.

*Oriostoma plana n. sp.*

Pl. XIV, figs. 7, 8.

Shell discoid, with the apex of the spire varying from the plane of the upper side of the whorls to depressed, so that the umbilicus of the apical side is almost equal to that at the opposite side. Volutions 3 to 3½, contiguous, regularly rounded and as wide as high or wider, increasing very gradually in size. Surface marked by 10 or 12 sharp revolving bands, which become closer, more crowded and stronger toward the periphery. The interspaces are flat or slightly concave, and about 1½ times as wide as the bands. These bands are crossed by very fine, clearcut, imbricating lamellæ, which arch slightly backward between the revolving bands, and swing forward across the ridges of the latter. The lines of growth, however, as seen in well-preserved casts, are much finer, more numerous, closer and less regular than the imbricating lamellæ, and arch *forward* between the ribs and swing gently *backward* across the ridges. These lines of growth are crossed by extremely fine revolving lines, barely visible under a strong lens.

In the number and disposition of its revolving ribs and in the depression of the spire, this very prettily marked shell is intermediate between *O. angulatum* and *O. lineatum*. In the finer markings there is some resemblance to *Poleumita scamnata*, but that

species as described and figured by Clarke and Ruedeman is clearly different from our shell.

The type specimen from Georgetown has a width of 18 mm. The body whorl just back of the mouth is 8 mm. wide. The height of the shell (the height of the body whorl) is 7½ mm. A second specimen from Georgetown has these respective dimensions: 15 mm., 7 mm., 6¾ mm.

### *Oriostoma sp. undet.*

Pl. XIV, figs. 1, 2.

Shell large, turbinate. Volutions five in number, the apical one minute, the lower ones increasing in size rather rapidly, but regularly; whorls subcircular in cross-section. Sutures transverse, impressed, exposing nearly all of the whorl above. The upper portion of the volution is flat or very much depressed, convex; from this, broadly rounding off in subangular arches toward the umbilicus. Umbilical and apertural characters unknown.

Surface marked by low, unequal, longitudinal ribs, which are rather distant and narrow. These are crossed by peculiarly wavy, transverse striæ. From the suture to the first rather prominent rib, a distance of 2½ mm., the striæ arch backward; but thereafter, between each pair of ribs they arch forward. These markings are on the inside of the outermost layer or else on the outside of the next inner layer of the shell, and correspond in position and in direction to those on the "casts" of *O. plana.*

In the outline of the body whorl, and especially in the flattened upper portion, there is a resemblance to *Pleurotomaria eloroidea,* and this resemblance is increased by the low ribs. But the peculiar direction of the transverse striæ is sufficient evidence to include the shell described above in the genus *Oriostoma,* or perhaps in *Poleumita.*

One specimen. Huntington.

### *Schizolopha sp.*

Pl. XII, fig. 3.

A single shell belonging to the State Museum has the following characters:

Medium-sized, turbinate; slightly higher than wide. Aperture two-fifths and body whorl two-thirds the height of the spire.

Mouth (as shown by the lines of growth) very deeply notched. Slit-band convex, not quite vertical, producing a subangular periphery. Profile above the slitband depressed, almost horizontal, forming a broad, low, double curve to the suture. Surface marked by distant, strongly elevated lines of "growth." Between these strong lines are 6 to 20, usually 12 to 15, very fine, even, raised lines, parallel to the lines of growth. The whole is crossed by fine concentric, revolving, raised lines, intermediate in strength between the two kinds mentioned above. The revolving lines are two or three times as far apart as the finer lines of growth. The species differs from *Clathrospira* in the convex slit-band. The aperture is not exposed, so that the presence of a slit is doubtful. In all other characters there is a generic resemblance to *Schizolopha moorei* Ulrich.

Should our species prove to be new, as it probably is, we would suggest the specific name, *S.* (?) *prosseri,* named after Prof. C. S. Prosser, of the Ohio State University.

One specimen. Delphi.

### *Cyclonema cancellata* Hall.

Pl. XIV, figs. 5, 6.

A small but very well preserved specimen has the following characters:

Shell small, turbinate; volutions four or more, the upper ones small, rapidly but regularly increasing in size to the body whorl, which is very large, and constitutes six-sevenths the height of the spire. The whorls are, as shown by the mouth, oblique-vertically oval in section. The outer lip is not perceptibly expanded. The inner lip is slightly reflexed and is produced anteriorly so that the small umbilicus is exposed nearly at the middle of the length of the shell. The sutures are deeply impressed and quite transverse. Shell substance extremely thin, covered by revolving lines, one of which, near the periphery, is only slightly more prominent than the others. These lines are obsolescent in the umbilicus, and then become subequal, frequently double and about twenty in number up to the near suture, where they suddenly terminate. The interspaces are wider than the striæ. Just below the suture there is a smooth space with three or four hardly perceptible, revolving lines.

The shell is marked also by extremely faint but distinct, raised transverse striæ, which extend obliquely backward from the suture across the longitudinal striæ. The latter are very much stronger than the transverse striæ.

The height of the shell is approximately 9 mm.; thickness, 6 mm.; width, 8 mm. The species may be recognized by the turbinate-turriculate outline, and by the fine revolving and finer transverse striæ. There is a strong resemblance to the *Turbo* (*Cyclonema*) *tennesseensis* of Roemer, but that species has forty revolving lines, while ours has about twenty, a few of which, however, are double. In the Georgetown specimen the transverse striæ are very much closer than in the *Cyclonema cancellatum* from the Clinton green shale of New York State.

Rare. Georgetown.

### *Cyclonema elevata* Hall.

Pl. XIII, figs. 3, 5.

Shell turriculate, height 1½ times the width. Spire consisting of five volutions, which increase very gradually in dimensions. Volutions in the casts regularly rounded, but the surface (which has never before been known) shows that the upper part of the body whorl is depressed convex, almost flattened, while the lower part is ventricose. The surface is marked by from four to six low longitudinal ribs, which become obsolescent on the upper and lower portions of the body whorl and on the upper portions of the older whorls. There are obscure lines of growth. The lower two-thirds of the whorl next to the body whorl shows three or four ribs. There is no median keel, nor is there any appearance of there having been a slit. A very narrow but distinct umbilicus is present.

This species may be distinguished from *Eunema* (?) *trilineata* by the greater narrowness of the latter. If *E. trilineata* really is a *Eunema* it should have no umbilicus whatever, and this is, therefore, another distinctive character.

The two specimens known, which are both larger than the Wisconsin forms, have a length of 35 mm. and a width of 24 mm.

An external mould of *Cyclonema elevata* has been obtained at Huntington, Ind. Another specimen, consisting of an external mould and its internal cast, was found in the quarries (5/A) one mile east of Huntington.

## CEPHALOPODA.

### *Orthoceras medullare* Hall.

Pl. XIX, figs. 1, 2.

Shell a longicone, large, sides straight, tapering at an angle of from 9-12 degrees. Section circular or subcircular, broadly elliptical when compressed. Chambers deep, siphon central, tubular, not at all expanding between the septa. The chambers do not perceptibly deepen with age. In one specimen having a width of about 36 mm. the chambers are 17 mm. deep. In another large specimen the chambers are 24 mm. deep where the shell is 63 mm. wide. Surface without annulations or longitudinal ridges; the specimens of Hall and of Meek and Worthen show, however, beautifully cancellating striæ.

The species may be recognized by the distant septa and the absence of either annuli or ridges in the cast.

Ten large specimens have been obtained at Delphi, and one large specimen from a locality one mile west of Anderson.

### *Orthoceras* (*Kionoceras*) *orus* Hall.

Pl. XXI, fig. 1; Pl. XXV, fig. 2.

Shell a longicone, large, tapering quite rapidly; section broadly oval, sometimes becoming circular or narrowly oval through rock pressure. Septa fairly distant, deeply concave; siphon small, placed three-sevenths the distance from one side to the other. Casts marked by longitudinal ridges; no annulations. Depth of the chambers varying from one-fourth to one-third the width.

Several specimens of body chambers from Huntington are referred to this species. These, together with a specifically identical chamber from Delphi, are circular or subcircular except when evidently much crushed, and bear the longitudinal ridges at the base. Higher up, these ridges become obsolescent. Just behind the mouth there is a broad constriction, below which the chamber is cylindrical. These body chambers are usually about 35 mm. wide and about 65 mm. high.

A narrowly ovate specimen from Wabash, now in the Indiana State Museum, is 175 mm. long, 35 mm. wide at one end and 54

mm. wide at the other. It shows 17 chambers in that distance. A couple of specimens from west of Anderson may be referred to this species.

Rather common. Huntington, Delphi, Wabash and Anderson.

### *Orthoceras (Kionoceras) delphiensis n. sp.*

Pl. XX, figs. 1, 2.

Shell large, straight, tapering slightly, sides almost parallel. Section circular, with tubular siphon between the center and the margin or submarginal surface marked by low, narrow longitudinal ridges, of which there are eleven in 75 mm., at a point where the shell is 47 mm. thick. The ridges are perceptibly closer on the side on which the siphon is situated, where they seem also to be more pronounced. The interspaces are concave, several times as wide as the ridges, and seem to have been covered with coarse longitudinal striæ. There are also transverse striæ. The body chamber is a little constricted just back of the mouth.

The type specimen now in the Indiana State Museum is a fragment with a length of 162 mm., a width of 50 mm. at the mouth, and of 45 mm. about 120 mm. further back. The shell and siphon are greatly thickened.

This species may be recognized by the narrow and distant ridges, the absence of annulations, the slightly constricted mouth and thick submarginal siphon. The large size and straight sides are also distinctive features. It is hardly separable from the *Orth. angulatum* of Worthen, which shows the same thickening of the siphon. In Wahlenberg's species, however, the siphon is more nearly central, and there are some minor differences.

Besides the type, three other fragments have been found at Delphi.

### *Orthoceras (Kionoceras) kentlandensis n. sp.*

Pl. XXI, fig. 2.

Shell a longicone, small, sides straight, slowly tapering. Section slightly oval (due to pressure ?); septa distant, almost flat; siphon large, eccentric. The depth of the chambers is more than half the width of the shell, except near the body chamber, where a few septa become crowded. Surface marked by longitudinal ribs which are quite faint in the cast.

This species is known from a single cast now in the Indiana State Museum (No. 685), which has a length of 78 mm., width at upper end 11 mm., at lower end 7 mm. At the lower extremity there are seven chambers in 32 mm., but just below the body chamber there are only five compartments in 9 mm. Twelve mm. above the base of the body chamber is a raised line, origin unknown.

This form can be recognized by its very distant septa. From *Orth. jolietensis of* Meek and Worthen, this species may be distinguished by the absence in the former of the longitudinal ridges, and the shallowness of the septa in the latter. Our species is also a much smaller shell.

Rare. Kentland.

### *Orthoceras* (*Geisonoceras*) *niagarense* Hall.

20th Rep. N. Y. State Cab. Nat. Hist., p. 356, pl. 20, fig. 3.

The following is Hall's description:

"Shell elongate, gradually tapering; section broadly elliptical; septa deeply concave; depth of chamber 5 lines where the diameter is 1½ inches; siphuncle eccentric. Surface annulated by low, rounded annulations which are from one to two inches distant, according to the size of the shell; intermediate spaces regularly concave. In the larger parts of the shell there are about three annulations to each chamber. The finer surface markings unknown. The section in all the specimens examined is elliptical."

An important feature which Hall figured but failed to describe is the fact that the undulations are very oblique, especially on the wider portions of the shell, but become less oblique in the successive older parts of the same.

A single fragment is referred to this species, 54 mm. long, 14 mm. wide at the lower end, and 18 mm. wide at the upper end. The cross-section is elliptical and the septa are deep so that it corresponds almost exactly with the above. The annulations, though, are weaker and fewer in number, and the chambers comparatively deeper in our specimen, but these are characters which one would expect to find in the young of such a species.

Rare. Quarry one mile west of Anderson.

### *Orthoceras (Dawsonoceras) cf. annulatum* Sowerby.

Pl. XIX, figs. 3, 4.

The Gilbert collection contains a fragment of an *Orthoceras* which is very closely allied to this species. The specimen is nearly 90 mm. long, 58 mm. wide at the broader end, and shows seven sutures in that distance. The annulation is not midway, between the sutures, but is nearer the older suture. The shorter slope of the annulation is depressed convex, and the longer slope with the normal concavity.

Rare. Huntington.

### *Orthoceras (Dawsonoceras) annulatum var. americanum* Foord.

Shell a longicone, small to medium sized; slowly tapering; section circular. Characterized by strong annulations, with concave interspaces; the suture in the middle of each interspace. Septa deep, siphon central. The depth of two or three chambers is equal the breadth of the shell. Surface marked by transverse and longitudinal striæ.

It can be recognized readily by the character of the annulations, which are always strong in casts.

The collection contains about ten fragments, the largest 33 mm. wide. None of the surface striæ are preserved.

Rather common. Delphi.

### *Orthoceras (Kionoceras) angulatum* Wahlenberg.

Pl. XXI, fig. 3.

Shell tapering gradually. Septa distant about one-fourth the diameter of the shell; siphuncle central or subcentral. Surface marked by angular longitudinal ridges.

Rare. Anderson.

### *Trochoceras (Sphyradoceras) cf. desplainense* McChesney. (?)

20th Rep. N. Y. State Cab. Nat. Hist., 1867, p. 359, pl. 16, figs. 8–10.

Shell a torticone of 2 to $2\frac{1}{2}$ volutions, dextral spire very low; cross-section ovate, with flattened sides; siphuncle small, near ventral margin. Surface and casts marked by distinct, sharp ridges, directed backward across the sides and with flat or concave

interspaces. Fine markings consist of minutely cancellating, subequal, transverse and longitudinal striæ. (The description above is drawn mostly from that of Clarke and Ruedeman.)

A couple of fragments of casts apparently belonging to this species were found at Huntington.

### *Lituites marshii* Hall.

Pl. XXI, fig. 4.

The principal features are shown by the figure.

This species is distinguished by its slender and more numerous volutions from *L. bickmoreanus.*

Represented by a single specimen from Wabash.

### *Lituites* (*Ophidioceras*) *bickmoreanus* Whitfield.

Pl. XXV, fig. 1.

Shell large, thick, plane-coiled outer volution free and extending in nearly a straight line; subcircular in cross-section, depressed convex or nearly flattened on the back. Surface marked by broad bi-convex undulations, which have ventro-lateral sinuses, swing back across the side and develop a strong dorsal saddle. The undulations are obsolescent on the back and absent near the mouth. The base of the saddle is opposite the sinus of the third or a little nearer to that of the second undulation back. The interspaces are concave.

The finer surface markings according to Whitfield, consist of "almost microscopic lines which run lengthwise of the coils, and also in finer transverse lines of which three occupy the space of one of the longitudinal lines. The septa are moderately concave and are arranged at distances from each other less than that between the transverse undulations of the sides, so that ten of them occupy a distance equal to eight of the undulations."

This species may be readily recognized by its large size, and its low undulations, both of which characters distinguish it from *L. (O.)marshi,* and *L. (Trocholites) multicostatum,* etc., and also from *Trochoceras (Sphyradoceras) desplrinense,* the latter of which is not plane-coiled.

The species was described by Whitfield in the Bulletin of the American Museum of Natural History, Vol. I, No. VI, pp. 191-

192, Pl. xxi, Figs. 1-3. His specimens are from the dolomitic limestones of the Niagara group at Wabash City, Indiana. Our specimens agree very closely with Whitfield's species. The Huntington specimen is a fragment from just back of the mouth. It is about 60 mm. long, with a lateral width of 35 mm. and ventro-dorsal thickness of 30 mm. The angle at the dorsal saddle is a trifle sharper than that in Mr. Whitfield's figures.

Another large fragment was found at a mile west of Anderson (Madison County). The latter is from an individual which must have been over a foot in diameter. The septal sutures are preserved and show a low dorsal saddle, the result of a dorso-lateral sinus on each side. The saddle is under the third undulation from that at which the suture is observed on the ventral side. The dorso-ventral thickness in this specimen is greater than the lateral.

Rare. Delphi, Huntington, Wabash and Anderson.

### *Lituites (Ophidioceras ?) hercules carrollensis n. var.*

**Pl. XVI, fig. 1, and Pl. XVII, fig. 1.**

Shell very large, nautilian, with the body chamber free and extended in an arched line. Cross section ovoid, flattened on the sides, with ventral and dorsal faces rounded, the latter more broadly so; greatest breadth just above the center; ratio of breadth to thickness is 10 : 11. Siphon eccentric but not marginal. The casts are marked by very broad, low undulations, each with a dorsal saddle. Near the ventral side* there are some longitudinal ribs, but both styles of markings are very obscure in the internal casts.

This variety may be easily recognized by the very large size, the flattened sides, and the peculiar curvature.

The type is a fragment of the body chamber with a few septa which are indistinct. The fragment has a length of 190 mm., breadth 60 mm., thickness 67 mm. The body chamber is 150 mm. long, but when entire must have been at least twice that length. The septa are rather distant, directed backward across the sides, and are furnished with shallow lateral sinuses and a dorsal saddle. Another fragment has a breadth of 67 mm., and thickness

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*In the ventral side there is also observable in the type specimen a very shallow groove which should serve to place this form in the genus *Remeleceras*, provided that this groove is normal to this species.

of 75 mm. The depth of the dorsal saddle of the undulations is about 40 mm.

Represented by two specimens from Delphi.

### *Trimeroceras gilberti n. sp.*

Pl. XV, fig. 1.

Shell breviconical, large, the lower portions of the ventral and dorsal sides converging at an angle of nearly 50 degrees. Section ovoid, rather pointed ventrally. Septa distant, 8 in 45 mm. There is a distinct saddle at the ventral side and an azygous sinus at the dorsal, with only one very shallow sinus on each lateral face. Body chamber large, broader than high. Siphuncle one-third the distance from the ventral face to the center. Dorsal periphery of the body chamber vertical, ventral periphery divergent from the base, both depressed convex. The upper side of the body chamber is rather flat, and parallel to the plane of the basal edge. The slit is narrow. Character of the apertural lobes unknown. Surface of septa with rather weak longitudinal ribs. Following are some statistics regarding these forms:

| | | | |
|---|---|---|---|
| Length of specimen with body chamber and 11 septa..... | | | 135 mm. |
| Length of the eleven septa..... | | | 80 mm. |
| Length of body chamber.....(1) | 72 mm. | (2) 75 mm. | (3) 83 mm. |
| D.-V. thickness at base (body ch.).... | 88 mm. | 87 mm. | 89 mm. |
| D.-V. thickness half way up (body ch.) | 101 mm. | 100 mm. | 112 mm. |
| Lateral thickness at base (body ch.).. | 68 mm. | 63 mm. | 65 mm. |

(1), (2), and (3) refer to 3 other specimens.

The species is readily distinguished by its rapidly tapering, conical shape. The body chamber is recognized by the parallel bases and subordinate height. There is a resemblance to *Phragmoceras nestor, var. canadense* Whiteaves, from which our species differs in having the upper and lower bases of the body chamber parallel. Named after Mr. Gilbert, to whose kindness in loaning material the opportunity of studying much of the Huntington *Gasteropoda* and *Cephalopoda* is due. The type and specimens described above are from Huntington, Ind.

Rare. Huntington and Delphi.

### *Hexameroceras delphicolum* Newell.

Proc. Bost. Soc. Nat. Hist., Vol. XXIII, p. 479, figs. 1-4.

Shell an arcuate brevicone, medium sized; transverse section broadly ovoid, almost pointed at the ventral side; greatest breadth

eleven-twelfths of the thickness and situated two-thirds of the distance to the dorsum; siphon ventral, submarginal.

Chambers shallow, three of them with a total depth of 8 mm. on the ventral side and 16 mm. deep on the dorsum. Septa almost flat. Sutures straight with no perceptible sinus or saddle. The chamber adjacent to the body chamber has half the depth of those following it, and has the anterior margin crenulated. The body chamber is dome-shaped, wider than high, with all the sides rounded and with a contracted aperture. The dorsal opening of the living chamber is furnished with three lateral lobes on each side of a narrow median slit which connects them with the single ovate ventral opening. The length of slit and opening equals about five-sixths of the dorso-ventral diameter.

Faint indications of fluted longitudinal markings are present on the septæ. The body chamber is 25 mm. high, 39 mm. wide and 43 mm. deep. The specimens described differ from Newell's description of the species in having the margins of the septæ nearly straight instead of curved. In other respects the present specimen agrees closely with *H. delphicolum*.

Rare. Huntington.

### *Cyrtoceras gorbyi* Miller.

One specimen from Huntington is referred to this species.

### *Gomphocera wabashensis* Newell.

Pl. XX, figs. 3, 4.

Shell a brevicone, small, straight. Septa of moderate depth; siphon moniliform, situated one-third to one-half distance from ventral margin to center. Body chamber conical with the sides nearly straight, converging toward the apex at an angle of about 20 degrees. Aperture simply T-shaped, without any accessory lobes. Cross-section circular to broadly oval.

It may be distinguished from *G. scrinium* by the more conical and proportionally longer living chamber.

This species is quite abundant at Huntington, where about ten specimens have been found. They are preserved as casts of the body chamber. The largest has a height of 53 mm., thickness at the base 40 mm., breadth 34 mm. Another large specimen has a thickness of 39 mm., and width of 36½ mm. The smaller forms are circular in cross-section.

There is a single specimen in the Indiana State Meseum which, labeled *G. subgracile,* is from Delphi.

A single specimen was found at Georgetown.

### *Phragmoceras parvum* Hall and Whitfield.

Shell a small, arcuate, brevicone. Septal portion half the length. The species may be easily recognized by its small size, the tubular extensions of the aperture, and the sharp angle formed by the edge of the aperture and the plane of the base of the body chamber. In all of the figured and described specimens the ventral periphery of the body chamber is convex; but of the two specimens from Huntington, it is flat in one and very concave in the other, which is the specimen figured. This is the only difference to be detected between specimens from Huntington, and those from the Guelph of Canada and New York. The second specimen is a little larger than the one figured.

Common. Huntington.

### *Phragmoceras angustum* Newell.

Pl. XVIII, fig. 1.

Shell large, arcuate; narrowly elliptical in cross section; increasing regularly in dorso-ventral diameter from the smallest cammera to the aperture.

Living chamber elongate, length greater than greatest dorso-ventral diameter. Length of aperture about equal to greatest length of living chamber. Apertural margins not well preserved, but they appear to consist of a small oval opening at the antero-ventral angle and a larger similar opening at the antero-dorsal angle, not connected by a narrow slit. The sutures of the cammera form broad, shallow lateral lobes and have ventral saddles.

The two specimens described are from Grant County. The type locality of the species is Wabash.

### *Phragmoceras cf. ellipticum* H. and W.

Pl. XIX, fig. 5.

The following is the original description taken from p. 152, Pal. Ohio. II.

"Shell of large size, slightly curved, transverse section narrowly elliptical, a very little wider on the outer than on the inner side of the center. Outer chamber wider than high; very depressed

convex on the sides, and sharply rounded on the ventral and dorsal edges; the ventral side extended at the aperture, forming a tube-like projection; the remainder of the aperture not known. First chamber below the chamber of habitation very shallow; septa deeply concave; siphuncle large, situated close to the inner side of the shell.

"Formation and locality. In the limestones of the Niagara group, in Highland County, Ohio, associated with *Trimerella ohioensis.*"

A large fragment corresponding very well with this species occurs in the Gilbert collection. The base of the body chamber is 6 mm. thick and 39 mm wide. Measured along the center there are five chambers in a depth of 25 mm. On the ventral periphery these five chambers occupy a depth of 19 mm. and on the dorsum of 36 mm. The penultimate chamber in our specimen is not differentiated from the others. The upper and basal peripheries of the body chamber are subparallel as in the Ohio material. The species may be distinguished by the large size, the subparallel bases of the body chamber and by the slight curvature.

Rare. Huntington.

The following additional species of Cephalopoda, represented in the collections at hand by very poor material or not at all, have been described from the Niagara rocks of the Wabash Valley by Frederick H. Newell in the Proc. Bost. Soc. Nat. Hist., Vol. XXIII, pp. 466-486.

*Orthoceras crebescens* Hall.
Wabash City.
*Orthoceras unionensis* Worthen.
Wabash City.
*Orthoceras rigidum.*
Peru.
*Orthoceras obstructum* Newell.
Wabash City.
*Kionoceras strix* Hall & Whitf.
Wabash City.
*Gomphoceras linearis* Newell.
Wabash.

*Gomphoceras projectum* Newell.

Delphi.

*Hexameroceras cacabiformis* Newell.

Delphi.

*Pentameroceras mirum* Barrande.

Delphi.

*Ascoceras newberryi* Billings.

Delphi.

*Ascoceras indianensis.*

Delphi.

## TRILOBITA.

### *Illaenus armatus* Hall.

Pl. XXII, fig. 6.

Two small pygida are referred to this species. The proportions of length and breadth are respectively three to four, and five to eight. They differ from *I. ioxus* in having the greatest elevation near the posterior end, and in sloping very abruptly to the posterior margin.

Georgetown and Wabash.

### *Illaenus insignis* Hall.

Pl. XXII, figs. 1-5.

Glabella strongly convex, regularly arched from front to back. Anterior and posterior margins of the cranidium strongly rounded, the latter bending backward outside the dorsal furrows and terminating in minute triangular pieces (the fixed cheeks) articulating with the free cheeks. Anterior margin with a thickened border. Dorsal furrows distinct, extending upward and forward from small pits in the occipidal groove; opposite the palpebral lobes they widen and deepen perceptibly for the space of one or two mm.; thence as shallow furrows curving downward and forward, they terminate in deep pits about one-third to one-half the distance from the front of the cranidium to the palpebral lobes. Free cheeks with rounded genal angles, sloping abruptly downward from the eyes.

Pygidium semicircular to slightly paraboloid in outline. Anterior margin broadly rounded in the median two-thirds of its

length, making a slight backward bend one-half the distance from the lateral margin to the middle, thence extending nearly straight to the antero-lateral margin. Surface but slightly convex on the top, but sloping rapidly to the margin at the sides.

This species is rather common. It occurs at Connor's Mill (Hamilton County), Delphi, Georgetown, Fishersburg and Wabash.

### *Illaenus ioxus* Hall.

Pl. XXII, fig. 7; Pl. XXIII, fig. 3.

Pygidium rather short, length equal to three-fourths the width or less. Posterior border regularly rounded forming nearly a semi-circle. Articulating margin broadly rounded, sometimes bending backward slightly just at the middle. Surface moderately convex sloping to the posterior margin quite gently.

Cephalon much broader than long. Only one poorly preserved cranidium has been seen. Five pygidia have been found in the collections from Pendleton, Fishersburg, Helm's Mill, and Connor's Mill, Hamilton County.

### *Ceratocephala goniata* Warder.

Pl. XXIV, fig. 13.

Cephalon subquadrangular in outline, width nearly twice the length. Glabella very tumid, consisting of a large median and three pairs of small lateral lobes. Median lobe narrowing slightly toward the front, its greatest width equal to half the length. Lateral lobes separated from the median lobes by deep furrows. Dorsal furrows very weak and indistinct, the lateral lobes merging into the fixed cheeks. One of the free cheeks is partially preserved, showing a nearly flat, broadly crescentric extension forming the antero-lateral margin of the cephalon. The strong ridges at the inner margins of the free cheeks support a pair of spine bases about midway between the genal angles and the anterior extremity of the cephalon. The occipital ring is separated from the glabella by a distinct but rather shallow groove. Two spine bases with a strong tubercle between occupy the ring. The border of the free cheek appears to have been ornamented with a fringe of tubercles or of fine spines. The genal angles terminate in strong diverging spines. The thorax and pygidium have not been seen.

The description is based on a single cephalon from Pendleton, which appears to be identical with the forms described from Bridgeport, Ill., by Hall as *Acidaspis danai* and by Winchell and Marcy as *A. ida.* The lateral gabella lobes are less distinct than in the figures of *A. danai et ida,* but this is due in part to a slight distortion of the specimen.

### *Odontopleura ortoni* Foerste.

**Pl. XXIV, figs. 16-19.**

Cephalon subcircular in outline, strongly convex with granulose surface; length about one-third the width. Median glabellar lobe of nearly uniform width throughout, length about two and one-third times the width, lateral lobes in three pairs separated from the median lobe by deep furrows. The anterior pair of lobes are very small and situated near the anterior extremity of the median lobe; the posterior pair are oblong masses just anterior to the occipital groove and about twice the size of the median pair. A pair of elongated, subtriangular elevations pointing forward, and flanking the lateral lobes, extend forward to the groove between the anterior pair of lateral lobes. A distinct low ridge extends backwards on each side from the antero-lateral margin of the median lobe to the eyes. Facial sutures not discernible. Lateral margins of the free cheeks set with numerous small spines, about one and one-half millimeters in length, pointing downward. The genal angles terminate in strong spines, which are broken off in the specimen figured. Occipital ring smooth, separated from the glabella by a distinct furrow.

Thorax with nine segments. Axis moderately convex, pleura flattened except at the extremities which are directed downward and terminate each in a sharp spine.

Pygidium very short; flat or slightly concave; axis convex and unsegmented. Margin of the pygidium with a fringe of twelve spines, each about as long as the pygidium, except the third pair from the posterior end which are longer than the others. This pair is continued across the pygidium, in oblique, convex ridges, converging to the anterior margin alongside the axis. The species is represented by two specimens—a nearly complete individual from Georgetown, and a pygidium from Pendleton.

### *Encrinurus indianensis n. sp.*

Pl. XXIV, figs. 14, 15.

Cephalon semicircular in outline; surface covered with large tubercles. Glabella with three very strong lateral tubercles on each side anterior to the occipital groove. Fixed cheeks separated from the glabella by very deep dorsal furrows. Genal angles apparently terminating in spines. Thorax unknown.

Pygidium elongate-triangular, strongly convex; the lateral lobes curve sharply down from the dorsal furrows to the margin. In the type specimen, the annulations of the axial lobe number 15; in each of the lateral lobes there are ten pleuræ, which are directed backward. Each annulation of the axis bears from three to five tubercles, the one at the middle of the annulation being the strongest. Three to six tubercles mark each of the lateral segments.

The cephalon and pygidium have not been found united, but the only *Encrinurus* cephalon found is from Connor's Mill, Hamilton County, which has furnished a number of *Encrinurus* pygidia all belonging to the species here described. This association makes the specific identity of the parts here figured very probable. This species seems to have no very close ally among described forms. The pygidium approaches somewhat to *E. variolaris* Brogn., from the Wenlock of England. The latter has nine to twelve annulations on the axis of the pygidium as compared with nine to fifteen in *E. indianensis,* and seven to eight pleura on the lateral lobes against nine to ten in the present species. The median annulations in *E. variolaris* (on the pygidium) have three tubercles, while the form here described has five except in the extreme posterior part, where the number is three.

Connor's Mill and Fishersburg (Hamilton County), Huntington, Little Deer Creek (Carroll County), and at Wabash.

### *Calymene cf. vogdesi* Foerste.

Pl. XXIV, figs. 1-7.

Cephalon semicircular; surface granulose, most coarsely so on the cheeks. A wide, flat band forms the anterior margin. Glabella varying from moderately convex to strongly tumid; lateral lobes of the glabella in three pairs, the posterior twice the size of the median pair, and the anterior pair very small.

Thorax with ten segments, axial lobe convex and elevated above the lateral lobes. Each annulation bears a pair of strong nodes, just above the dorsal grooves. The pleuræ are horizontal for one-third their length from the dorsal groove, then they bend abruptly downward, terminating in broad paddle-shaped ends; pleuræ grooved four-fifths the distance to their outer extremities.

Pygidium with nearly straight postero-lateral sides, their union making an obtuse angle. Axial lobe tapering gradually to a smooth rounded extremity; annulations eight or nine, the anterior three or four showing small indistinct nodes at the dorsal furrows continuous with those of the thorax. Lateral lobes with five or six annulations. The annulations are directed backward and are grooved along the outer half of their length.

This species is rather common; Connor's Mill (Hamilton County), Georgetown, and at "Hanging Rock" (Wabash County).

### *Ceraurus* (*Crotalocephalus*) *niagarensis* Hall.

Pl. XXIV, fig. 8; Pl. XXIII, figs. 1, 2.

This species is represented by three specimens showing the glabella and a portion of the fixed cheeks. The nearly straight anterior margin of the glabella shown by one of the figures is due to the imperfection of the specimen, the normal condition being rounded and tumid in front.

The specimen from Marion is of unusual size, the glabella measuring 50 mm. in length and 35 mm. in its greatest width.

Rare. Connor's Mill (Hamilton County), Marion and at Georgetown.

### *Sphaerexochus romingeri* Hall.

Pl. XXII, figs. 8, 9, 12-15

Glabella very large, constituting the bulk of the head, spheroidal in form, surface smooth. The posterior glabella lobes, resembling large tubercles, are limited by a pair of deep, semicircular grooves; the lobes are separated by a space equal to one and a half to two times their width. The free cheeks are small, subtriangular pieces extending downwards from the base of the posterior glabella lobes. Two or three specimens show two pairs of shallow linear grooves anterior to the posterior glabella lobes which extend upward and forward from the antero-lateral margin of the glabella. The posterior pair is the longer of the two. The free cheeks have not been

observed. Occipital ring highly arched, limited by a deep furrow. The largest specimen observed has a width of 31 mm., and a length of 23 mm. Another very spherical cephalon measures in width 21 mm., length 18 mm., height from base of posterior glabella lobes to the highest part of the glabella is 14 mm. Thorax unknown.

Pygidium transversely elliptical in outline, axis terminating in a triangular-shaped piece, anterior to which are three strong annulations; the lateral lobes are divided into three broad, simple pleura, the posterior pair directed backwards.

The marble-shaped glabella of this species are among the most common and generally distributed fossils of the Niagara of northern Indiana. It is worthy of note that this species, so common throughout northern Indiana is entirely absent from the Niagara fauna in the vicinity of the Falls of the Ohio.

### *Phacops cf. pulchellus* Foerste.

Pl. XXIV, figs. 9, 12.

Cephalon ovate to semicircular in outline, proportions of length to breadth as five to eight. Anterior end with a narrow thickened border; genal angles rounded. Occipital groove well marked, with deep pits at the intersections with the dorsal furrows. A deep groove also terminating in pits in the dorsal furrows crosses the constricted base of the glabella; anterior to this groove, in some specimens two pairs of very weak lateral furrows mark the sides of the glabella, opposite the palpebral lobes. Most specimens show no trace of these furrows. The frequent absence of these furrows, and their slight development when present, constitute the principal difference between Foerste's species and the forms here described.

Thorax unknown. Pygidium semicircular in outline posteriorly, anterior margin slightly rounded. Axial lobe strongly elevated above the lateral lobes, width equal to three-fourths that of the lateral lobe; profile regularly arched from the anterior to the posterior extremities. The annulations on the axial lobe are about nine in number, and arch slightly backward in crossing the top of the lobe. The median row of tubercles characterizing the axial lobe of *P. pulchellus* is absent. Lateral lobes with five or six segments, each with a median groove; the pleuræ become indistinct posteriorly and the surface nearly smooth opposite the posterior end of the axis.

Rather common at Connor's Mill. Rare at each of the following localities: Georgetown, Pendleton, and Connor's Mill.

*Dalmanites* (*Symphoria*) *vigilans* Hall.

Pl. XXIV, fig. 20; Pl. XXIII, figs. 4-7.

Pygidium depressed, elongate triangular, terminating in a sharp point or spine. Axial lobe with ten to twelve annulations. Lateral lobes with about ten pleurae directed backward, flattened and traversed by a median furrow.

The species is represented by a few fragmentary pygidia from Anderson, and by a cephalon from Pendleton.

TABLE SHOWING DISTRIBUTION OF NIAGARA FOSSILS IN NORTHERN INDIANA.*

*This list includes only those localities from which collections sufficiently full to be representative of the local faunules were obtained.

TABLE SHOWING DISTRIBUTION OF NIAGARA FOSSILS IN NORTHERN INDIANA—Continued.*

| | | Little Deer Creek. | Georgetown. | Pendleton. | Wabash. | Delphi. | Huntington. | Connor's Mill. | Helm's Mill. | Fishersburg. | Bunker Hill. | Goodland. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45. | | | a | o | r | | | + | | o | | |
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| 47. | | a | | | | | | | | | | |
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| 50. | | | | | r | r | | | | | | |
| 51. | | | | | r | | | | | | | |
| 52. | | | | | r | | | | | | | |
| 53. | | | r | | | | | | | | | |
| 54. | | r | | | | | | | | | | |
| 55. | | | r | | | | | | | | | |
| 56. | | | | | r | | | | | | | |
| 57. | | | | | r | | | | | | | |
| 58. | ornutum | a | r | | | | | a | + | | | |
| 59. | | | r | | | | | | | | | |
| 60. | | | | | | + | + | | | | | |
| 61. | | | | | | | r | | | | | |
| 62. | | | | | | r | | | | | | |
| 63. | | | | | | r | | | | | | |
| 64. | Pleurotomaria pauper | | | | | | a | | | | | |
| 65. | Pleurotomaria (Eotomaria) laphami | | | | | r | | | | | | |
| 66. | Pleurotomaria (?) axion | | | | | | | | | | | |
| 67. | Pleurotomaria (Euomphalopterus) alatus var. | r | | | | | | | | | | |
| 68. | ) var. lima- | | | | | a | | | | | | |
| 69. | | | | | | r | | | | | | |
| 70. | | | | | | | r | | | | | |
| 71. | | | | | | | a | | | | | |
| 72. | a | | | | | | r | | | | | |
| 73. | | | | | | | a | | | | | |
| 74. | | | | | | | + | | | | | |
| 75. | ornatum | | | | | | + | | | | | |
| 76. | | | r | | | | | | | | | |
| 77. | | | | | | | + | | | | | |
| 78. | | | | | | r | | | | | | |
| 79. | | r | | | | | | | | | | |
| 80. | | | | | | | r | | | | | |
| 81. | | | | | | a | | | | | | |
| 82. | | | a | r | | | | | | | | |
| 83. | alatum | | | | | | r | | | | | |
| 84. | | | | | | r | + | | | | | |
| 85. | | | | | | r | | | | | | |
| 86. | | | | | | | r | | | | | |
| 87. | | | | | r | | | | | | | |
| 88. | ius | | | | r | | r | | | | | |
| 89. | carrollensis | | | | | r | | | | | | |
| 90. | | | | | | | r | | | | | |
| 91. | s | | r | | | | | | | | | |
| 92. | | | | | | r | + | | | | | |
| 93. | | | | | | | r | | | | | |
| 94. | | | | | | | r | | | | | |
| 95. | | | | | | | r | | | | | |
| 96. | | | r | | r | | | | | | | |
| 97. | | + | a | | | r | +? | a | | a | | |
| 98. | | | | + | | | | | | | | |
| 99. | | | | | | r | | | | | | |
| 100. | | | | r | | | | | | | | |
| 101. | | | r | | | | | | | | | |
| 102. | | a | | a | | r | r | a | | a | | |
| 103. | | | a | + | | | | a | | | | |
| 104. | nsis | | r | | | | | r | | | | |
| 105. | | r | a | a | a | r | | a | + | a | | |
| 106. | | | | r | | | | a | | | | |
| 107. | | | | + | | | | | | + | | |

*This list includes only those localities from which collections sufficiently full to be representative of the local faunules were obtained.

# PLATES FOR PAPER

ON THE

# Stratigraphy and Paleontology

OF THE

## NIAGARA OF NORTHERN INDIANA.

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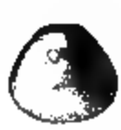

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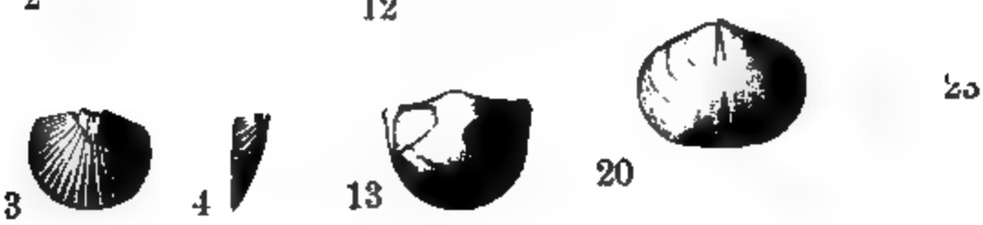

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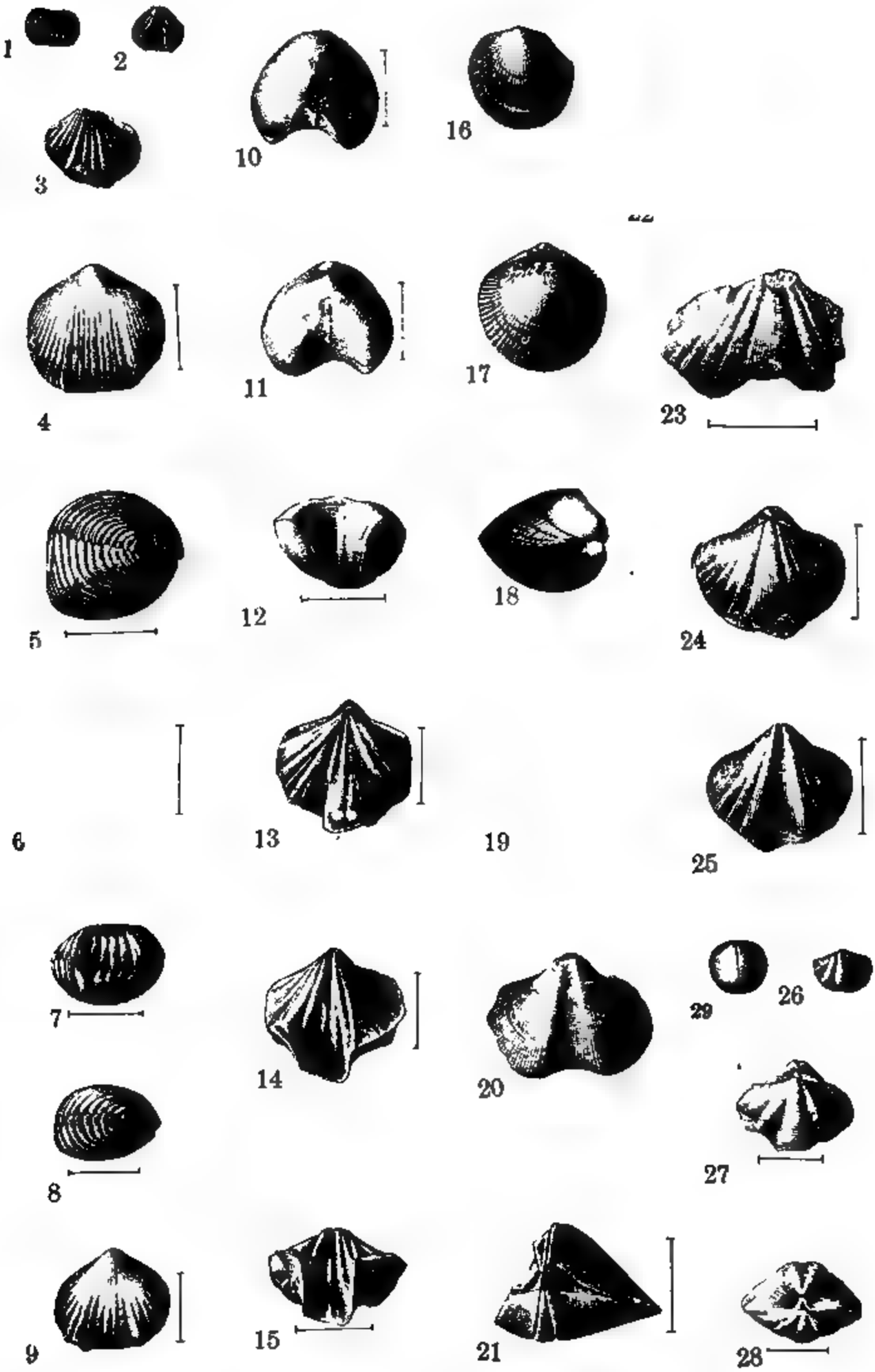
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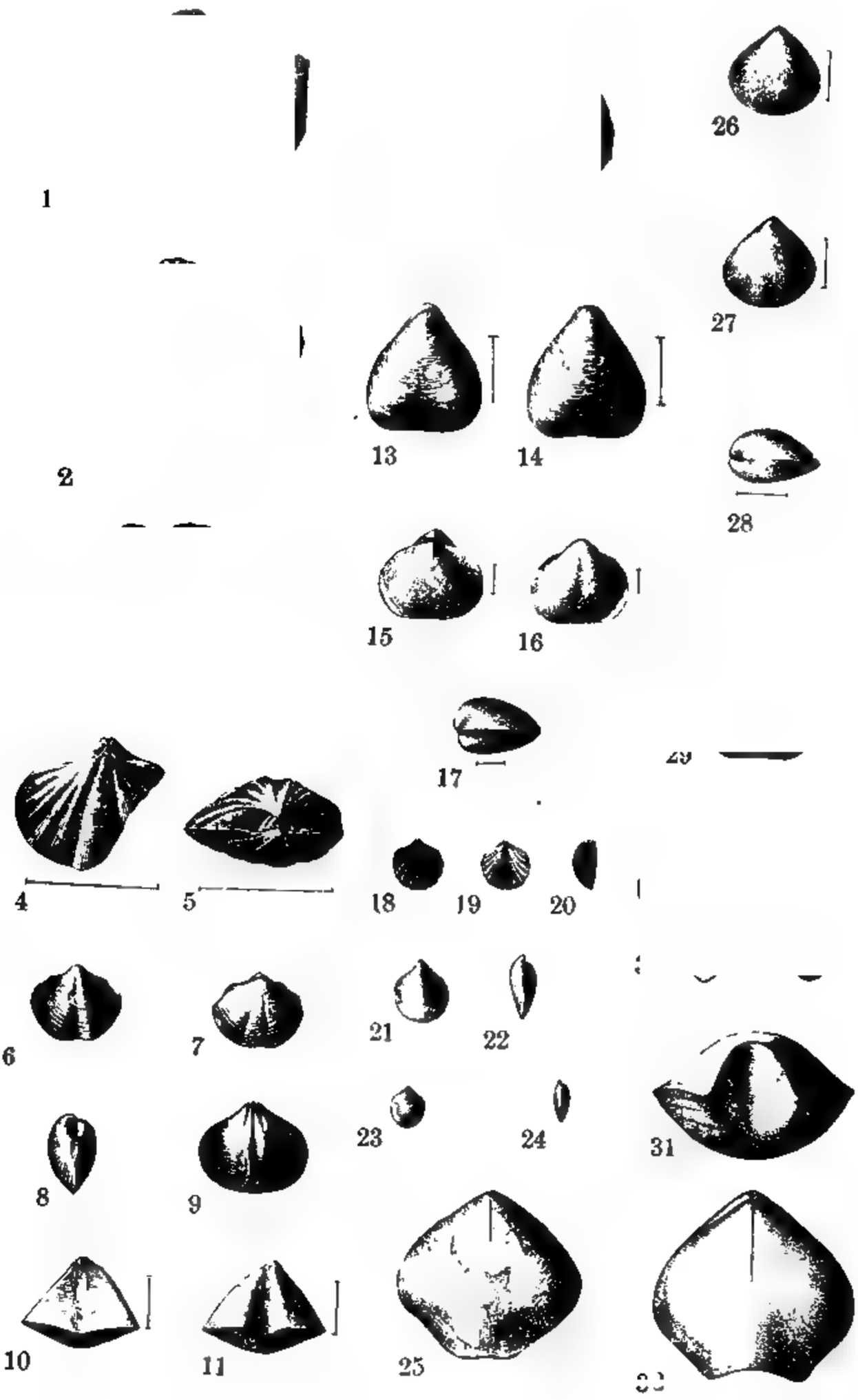
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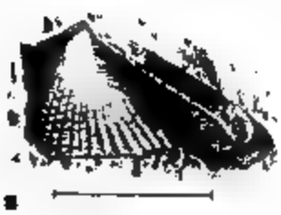

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Figs. 15-16. Two views of a specimen showing lamellose lines of growth.
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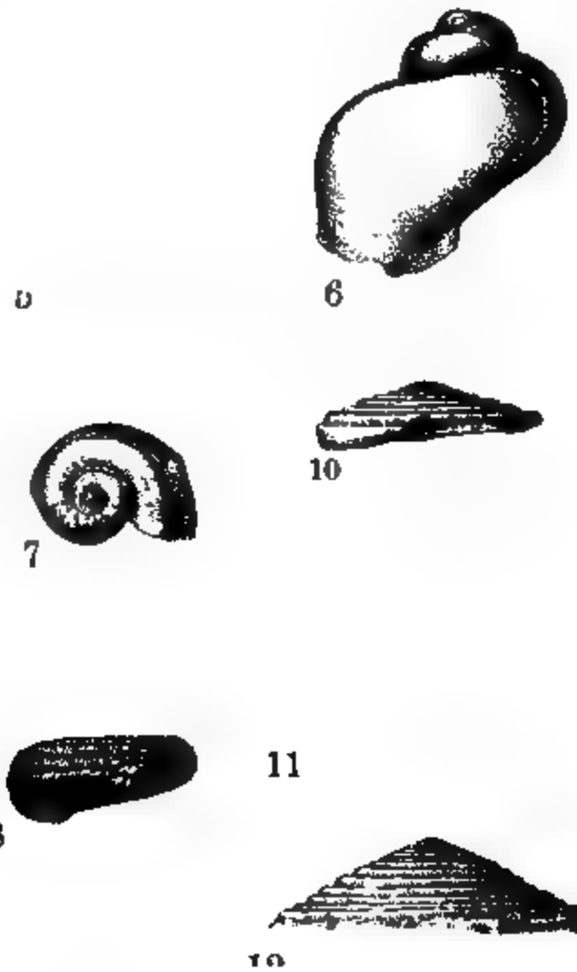

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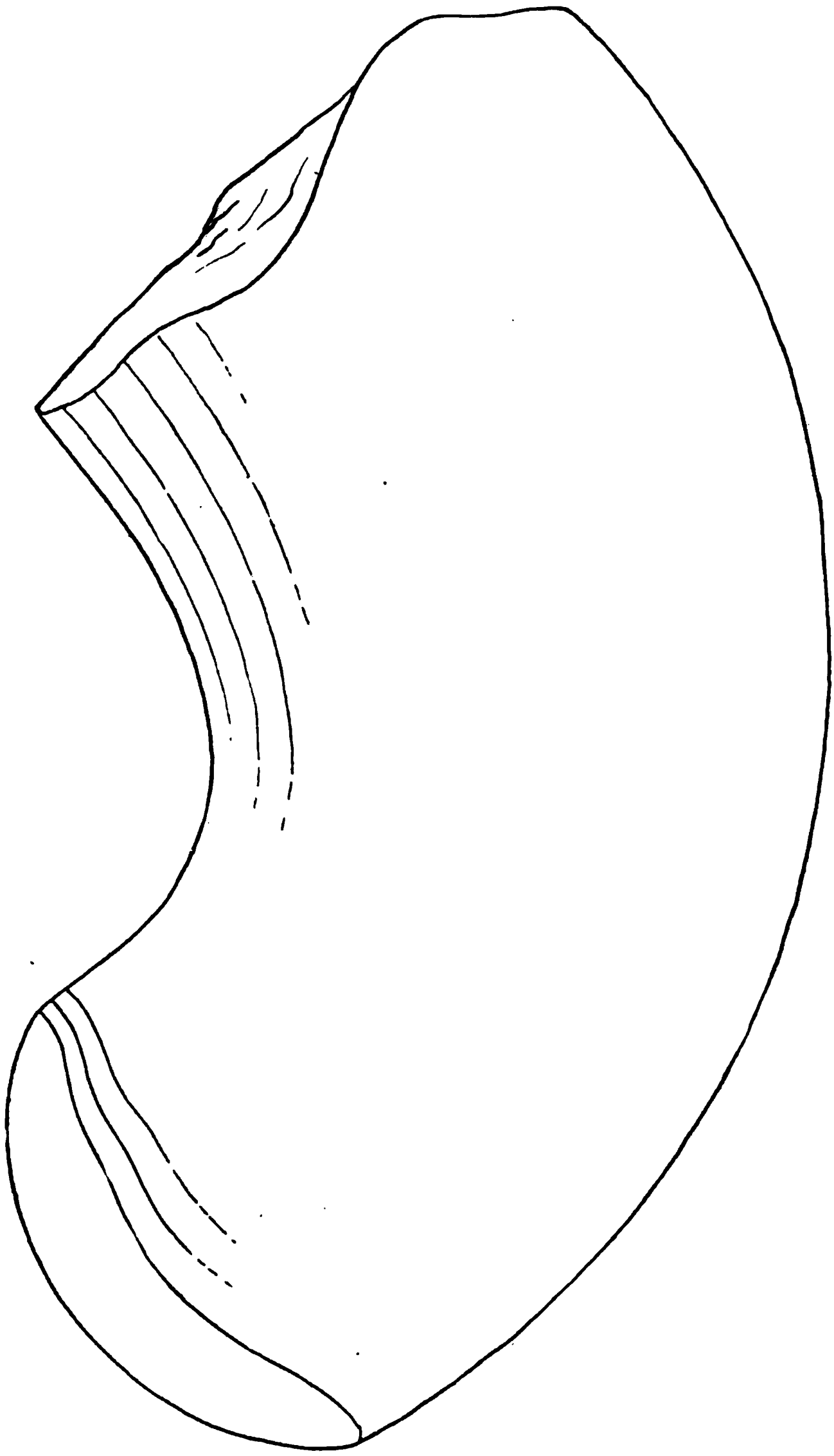

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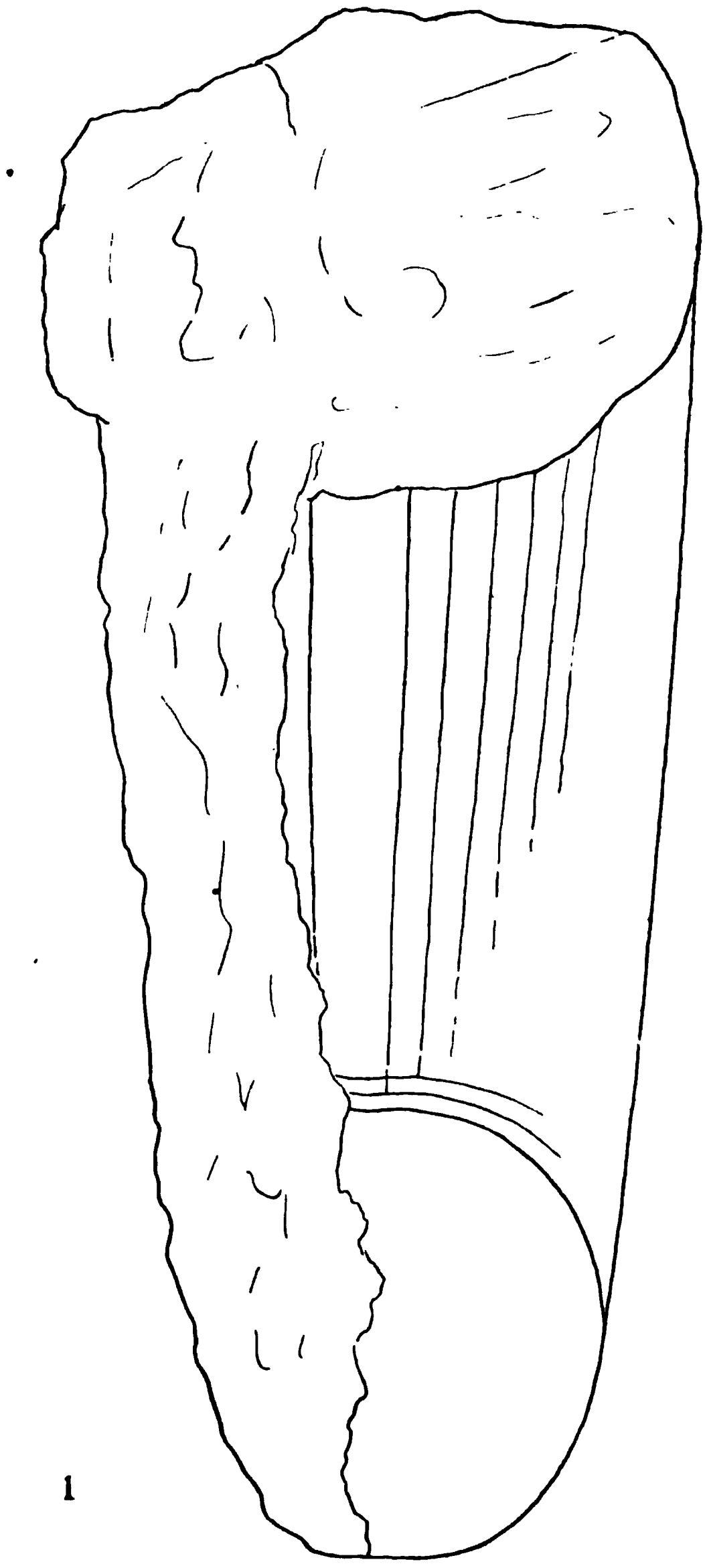

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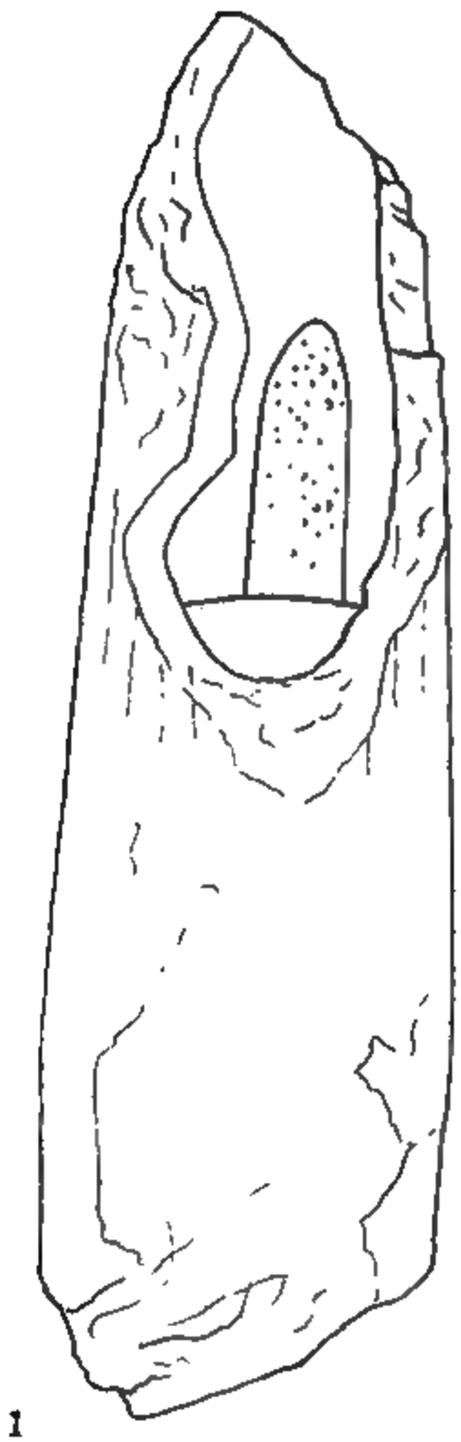

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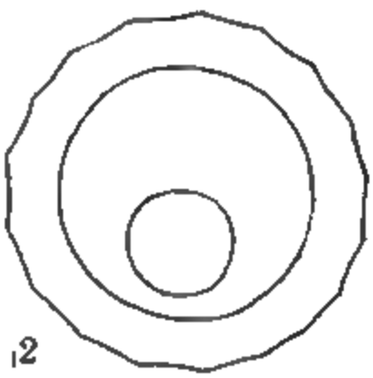

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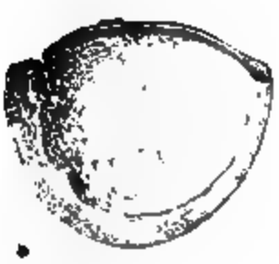

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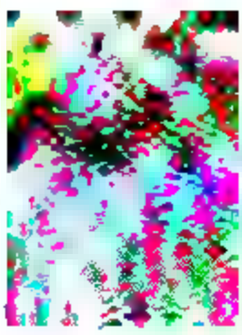

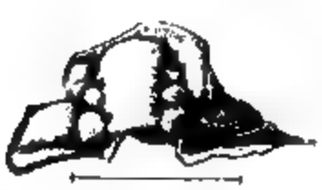

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# CONTENTS OF THE PUBLISHED VOLUMES OF REPORTS OF THE INDIANA GEOLOGICAL SURVEY; THE DEPARTMENT OF GEOLOGY AND NATURAL HISTORY, AND THE DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

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By T. C. Hopkins.

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*Report of a Geological Reconnaissance of the State of Indiana.*

Made in the year 1837 by D. D. Owen, M. D., State Geologist, and reprinted in 1859.

Part I. Leading principles of geology; Plan of conducting the survey; Summer survey, south of the National Road; Fall survey, north of the National Road; Remarks on the mineral deposits, soil and growth peculiar to the different strata; Summary and practical inferences; Appendix, Suggestions as to mode of conducting future surveys.

Part II. A continuation made in 1838: Posey County, Vanderburgh County, Warrick County, Spencer County, Dubois County, Harrison County, Floyd County, Clark County, Jefferson, Scott, Jennings, Ripley, Decatur, Rush and Shelby counties; Switzerland, Dearborn, Franklin, Union and Fayette counties; Wayne County; Counties north of the National Road and east of the second principal meridian; Carroll County, Montgomery County, Fountain, Clark and Vermillion counties, Clay County; Greene, Martin, Perry, Vigo, Sullivan, Knox, Daviess, Pike and Gibson counties. Comparison between the Muriatiferous rocks of Virginia and Ohio and those at the base of the coal formation of Indiana. Comparison between the geological formations of Indiana and those of Ohio. Summary of the Geology of Indiana. Analyses of rocks and minerals of Indiana.

*Geological Survey of the State of Indiana.*

Letter from Dr. R. T. Brown, published in the Transactions of the Indiana State Agricultural Society, 1853, pp. 299-332.

Contents: The Silurian; The Cliff Rock; The Argillaceous or Chemung Sandstone; The Mountain Limestone; The Coal Field; Iron Ore.

*Report of a Geological Reconnaissance of Indiana,* 1859-1860. Under the direction of the late David Dale Owen, State Geologist, by Richard Owen, Principal Assistant and now State Geologist, Indianapolis, 1862.

Contents: Report of Richard Owen containing preliminary observations and details of counties; Physical Geography; Chemical analyses of Indiana soils by Dr. Peter; Report on the distribution of the geological strata in the Coal Measures, by Leo Lesquereux; Report of J. Lesley, topographical geologist.

*First Annual Report of the Geological Survey of Indiana,* 1869. E. T. Cox, State Geologist.

Contents: Geology; Clay County; Greene County; Parke, Fountain, Warren, Owen and Vermillion counties; Franklin County, by Dr. Rufus Haymond.

*Second Report of the Geological Survey of Indiana,* 1870, by E. T. Cox, State Geologist, Indianapolis, 1871.

Contents: Report on coal; Daviess County, Martin County, Putnam and Vigo counties, Spencer and Warrick counties; Western Coal Measures and Indiana Coal; Sullivan County; Manual of Botany of Jefferson County, by A. H. Young.

*Third and Fourth Annual Reports of the Geological Survey of Indiana,* 1871 and 1872, by E. T. Cox, State Geologist, 1872; included in the Fourteenth Annual Report of the Indiana State Board of Agriculture, 1872.

Contents: Description of coal fields, Perry County; Geological Notes of a trip from New Albany, in Floyd County, to Harrison and Crawford counties; Report on the Wyandotte Cave and its Fauna, by Prof. E. D. Cope; Geology of Dubois County, Indiana; Geology of Pike County, Indiana; Geological Reconnaissance of Jasper, White, Carroll, Cass, Miami, Wabash and Howard counties; Geological Survey of Parke County; Geology of Dearborn, Ohio and Switzerland counties. Meteorology of Vevay, Switzerland County, Indiana; Manufacture of spiegeleisen, specular or glittering iron, by Hugh Hartmann.

*Fifth Annual Report of the Geological Survey of Indiana,* 1873, by E. T. Cox, State Geologist, Indianapolis, 1874.

Contents: Report on the Vienna Exposition of 1873; The iron and steel industries of Rhenish Prussia and Westphalia, Germany, at the Vienna Exhibition of 1873, by H. Hartmann; Spiegeleisen manufacture, by Hugh Hartmann; Geological Report; Geological Survey of Clark and Floyd counties; Geology of Warren County; Geology of Lawrence County; Geology of Knox County; Geology of Gibson County; Tripoli; Report of observations made in the counties of Dekalb, Steuben, Lagrange, Elkhart, Noble, St. Joseph and Laporte.

*Sixth Annual Report of the Geological Survey of Indiana,* 1874, by E. T. Cox, State Geologist, Indianapolis, 1875.

Contents: Geological Report; Antiquities; Jackson County; Geology of Brown County; Scott County; Jefferson County; The Sisco of Lake Tippecanoe and its Relatives, by D. S. Jordan; Synopsis of the Genera of Fishes to be looked for in Indiana, by D. S. Jordan; A partial list of the Flora of Jefferson County, by John M. Coulter.

*Seventh Annual Report of the Geological Survey of Indiana,* 1875, by E. T. Cox, State Geologist, Indianapolis, 1876.

Contents: Geological Report; Analyses of coals; Vigo County, Huntington County; Species of fossil marine plants from the Carboniferous Measures by L. Lesquereux; Jennings County; Ripley County; Orange County; Geological Report on Vanderburgh, Owen and Montgomery counties; Geology of the southeastern part of Clay County; Geological reconnaissance of the Coal Measure Rocks of Putnam County; Observations on the depth and temperature of some of the lakes of Northern Indiana, by G. M. Levette; Catalogue of the Flora of the Wabash Valley below the Mouth of White River, by J. Schneck.

*Eighth, Ninth and Tenth Annual Reports of the Geological Survey of Indiana,* 1876-7-8, by E. T. Cox, State Geologist, Indianapolis, 1879.

Contents: Report; Catalogue of Fossils found in the Hudson River, Utica Slate and Trenton Groups, by S. A. Miller; Hydraulic Cement; Building Stone; Glacial Drift; Antiquities; Porcelain, tile and potter's clays; Bessemer iron; Wayne County; Table of Altitudes; Catalogue and Check List of the Trees and Woody Shrubs of America, north of Mexico, by John W. Byrkit; Harrison County; Crawford County.

*First Annual Report of the Department of Statistics and Geology,* 1879. John Collett, Chief of Bureau. Statistical, no geology.

*Second Annual Report of the Department of Statistics and Geology,* 1880. John Collett, Chief of Bureau of Statistics.

Contents: Geology in Indiana; Mammoth and Mastodon remains in Indiana and Illinois; A Vincennes Mound; The Worthington Mound; Geology of Putnam County; Geology of Monroe County; Synopsis of the Molluscous Fauna of Indiana, by Frederick Stein; Fossils of the Indiana Rocks, by C. A. White.

*Eleventh Annual Report of the Department of Geology and Natural History,* 1881. John Collett, State Geologist.

Contents: Geology of Indiana; Mines and Quarries; Experiments upon the transverse strength and elasticity of Building Stones, by Thos. H. Johnson; Table of Altitudes; Geology of Shelby County; Fountain County; Geology of Delaware County; Geology of Bartholomew County; Description of the species of Fossils found in the Niagara Group at Waldron, Indiana, and plates, by Prof. James Hall.

*Twelfth Annual Report of the Department of Geology and Natural History,* 1882. John Collett, State Geologist.

Contents: General Economic Geology; United States surveys and growth of timber; Indian names of water-courses in the State of Indiana; Outline Geology of Indiana; Geological Survey of Newton County; Geological Survey of Jasper County; Geological Survey of Marion County; Geological Survey of Decatur County; Geological Survey of Jay County; Geological Survey of Randolph County; Catalogue of the Flora of Central-Eastern Indiana, by A. J. Phinney. Paleontology; VanCleve's Fossil Corals, by Prof. James Hall; The Spergen Hill Fossils, by Jas. Hall; Diatoms of the Waters of Indiana, by Rev. G. L. Curtiss.

*Thirteenth Annual Report of the Department of Geology and Natural History:* Part I, Geology and Natural History; Part II, Paleontology. John Collett, State Geologist, 1883.

Contents: Outline Geology of Indiana; Fuel Values of Coal Industry; Analyses of 390 Indiana coals and 56 other coals; Economic Geology of the State; Geology of Posey County; Geology of Morgan County; Geology of Rush County; Geology of Johnson County; Geology of Grant County; A Glossary of terms com-

monly used in Geological Reports, by W. T. S. Cornett. Paleontology; Principles of Paleozoic Botany and the Fauna of the Coal Measures, by Leo Lesquereux; The Fossils of the Indiana Rocks, No. 3, by Chas. A. White; A Geological Map of the State.

*Fourteenth Annual Report of the Department of Geology and Natural History:* Part I, Geology and Natural History. Part II, Post-Pliocene Vertebrates of Indiana. John Collett, State Geologist, 1884.

Contents: Introduction; Work of the Department; Geological map; Outline Geology of Indiana; Geological and topographical survey of Hamilton and Madison counties, by R. T. Brown; Geological and topographical survey of Fayette County, by M. N. Elrod; Union County, by M. N. Elrod; University Cave, Greencastle, Indiana; Indiana oölitic limestone, table of tests; Fish Culture in Indiana; The Drift Deposits of Indiana, by J. S. Newberry; The Ohio River Floods; Table of altitudes of Chicago and Indianapolis Air Line R. R.; A glossary of terms commonly used in geological reports; An account of the Mammalian Fauna of the Post-Pliocene deposits in Indiana, by E. D. Cope and J. L. Wortman.

*Fifteenth Annual Report of the Department of Geology and Natural History,* 1886. Maurice Thompson, State Geologist.

Contents: Compendium of Geology and Mineralogy; Indiana Building Stone; The Clays of Indiana; Indiana Chalk Beds; Glacial Deposits of Indiana; A Terminal Moraine in Central Indiana; Geology of Tippecanoe, Henry and Portions of Randolph, Wayne and Delaware, Washington, Clinton, Boone, Marshall, Hancock, Benton and Starke counties; The Wabash Arch, by S. S. Gorby; Geographical Botany; The Origin of the Indiana Flora, by John M. Coulter and Harvey Thompson; Fossil Mammals of the Post-Pliocene in Indiana; The Prehistoric Race in Indiana, by S. S. Gorby; Natural Gas; Glossary.

*Sixteenth Annual Report of the Department of Geology and Natural History.* Maurice Thompson, State Geologist, edited by S. S. Gorby, 1888.

Contents: Drift Beds of Indiana; The Wabash Arch; Fossils and their Value; Outline Sketch of the Most Valuable Minerals of Indiana; Gold, Silver and Precious Stones; The formation of Soils and other Superficial Deposits; Geology of DeKalb

County; Geology of Allen County; Partial Report of the Survey of the Western Division, including sketches of White and Pulaski counties; Characteristic plants of the Kankakee Region; Geology of Miami County; Natural Gas and Petroleum; Structural Features of Indiana; Sections of Natural Gas Wells in Indiana; Table of Altitudes in Indiana; Economic Use of Natural Gas; Paleozoic Crinoids, by S. A. Miller; Echinodermata of Indiana, Missouri and Iowa, by S. A. Miller and W. F. E. Gurley; The Work; The Flora of Dearborn County, by S. H. Collins; List of Specimens in the State Museum.

*Seventeenth Annual Report of the Department of Geology and Natural Resources.* S. S. Gorby, State Geologist, 1891.

Contents: Report upon the various Stones used for Building and found in Indiana; Geology of Steuben County; Partial Catalogue of the Flora of Steuben County; Geology of Whitley County; Geology of Carroll County; Geology of Wabash County; Partial List of the Flora of Wabash and Cass counties; Report of Inspector of Mines; Report of State Supervisor of Oil Inspection; Petroleum in Indiana; Report of Supervisor of Natural Gas; A Catalogue of the Butterflies known to Occur in Indiana, by W. S. Blatchley; The Batrachians and Reptiles of Indiana, by O. P. Hay; Paleontology, by S. A. Miller.

*Eighteenth Annual Report of the Department of Geology and Natural Resources.* S. S. Gorby, State Geologist, 1893.

Contents: Geology of Noble County; Flora of Noble County; Geology of Lagrange County; The Drift of the Wabash-Erie Region; Report of Inspector of Mines; Report of State Supervisor of Oils; Report of Supervisor of Natural Gas; Indiana's Structural Features as Revealed by the Drill, by E. P. Cubberly; Paleontology, by S. A. Miller.

*Nineteenth Annual Report of the Department of Geology and Natural Resources.* S. S. Gorby, State Geologist, 1894.

Contents: Geology of Cass County; Report of the Inspector of Mines; Report of the Supervisor of Oils; Report of the Supervisor of Natural Gas; The Lampreys and Fishes of Indiana, by O. P. Hay.

*Twentieth Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1895.

Contents: Natural Fuels; Resources other than Fuels; A Preliminary Report on the Clays and Clay Industries of the Coal Bearing counties of Indiana, by W. S. Blatchley; The Carboniferous Sandstones of Western Indiana, by T. C. Hopkins; The Whetstone and Grindstone Rocks of Indiana, by E. M. Kindle; Report of the State Natural Gas Supervisor; Report of the Inspector of Mines; Report of State Supervisor of Oil Inspection for 1894 and also for 1895; The Crawfishes of the State of Indiana, by W. P. Hay.

*Twenty-first Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1896.

Contents: The Natural Resources of Indiana, by W. S. Blatchley; The Petroleum Industry in Indiana, by W. S. Blatchley; Composition of Indiana Coals, by W. A. Noyes; The Black Slate or Genesee Shale of New Albany, Indiana, by Hans Duden; Indiana Caves and their Fauna, by W. S. Blatchley; A Report on the Geology of the Middle and Upper Silurian Rocks of Clark, Jefferson, Ripley, Jennings and Southern Decatur counties, by August F. Foerste; The Bedford Oölitic Limestone of Indiana, by T. C. Hopkins and C. E. Siebenthal; Report of the State Natural Gas Supervisor; Report of the State Inspector of Mines; Report of the State Supervisor of Oils; Geology of Vigo County, by J. T. Scovell; Catalogue of the Ferns, Fern Allies and Flowering Plants of Vigo County, by W. S. Blatchley.

*Twenty-second Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1897.

Contents: Geological Scale of Indiana, by W. S. Blatchley and Geo. H. Ashley; Geology of Lake and Porter counties, by W. S. Blatchley; The Clays and Clay Industries of Northwestern Indiana, by W. S. Blatchley; The Petroleum Industry in Indiana in 1897, by W. S. Blatchley; On the Advantages of Producing Beet Sugar in Northwestern Indiana, by E. L. Furness; A Report on the Niagara Limestone Quarries of Decatur, Franklin and Fayette counties, with Remarks on the Geology of the Middle and Upper Silurian Rocks of these and neighboring counties, by August F. Foerste; Reports of the State Natural Gas Supervisor, Inspector of Mines, and Supervisor of Oil Inspection; September Dragonflies of Round and Shriner Lakes, Indiana, by E. B. Wil-

liamson; A Catalogue of the Fossils of Indiana, by E. M. Kindle; The Birds of Indiana, by A. W. Butler.

*Twenty-third Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1898.

Contents: Coal Deposits of Indiana, by Geo. H. Ashley, 1565 pp. and numerous map sheets; Reports of State Inspector of Mines, Natural Gas Supervisor, Supervisor of Oil Inspection.

*Twenty-fourth Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1899.

Contents: Natural Resources of Indiana, by W. S. Blatchley; A General Discussion of the Middle Silurian Rocks of the Cincinnati Anticlinal Region, with their Synonymy, by August F. Foerste; A Report upon the Waldron Shale and its Horizon in Decatur, Bartholomew, Shelby and Rush counties, by J. A. Price; Reports of the State Inspector of Mines, Natural Gas Supervisor, Supervisor of Oil Inspection; The Dragonflies of Indiana, by E. B. Williamson; A Descriptive Catalogue of the Mollusca of Indiana, by R. E. Call; Notes on the Batrachians and Reptiles of Vigo County, by W. S. Blatchley; A Catalogue of the Flowering Plants and of the Ferns and their Allies Indigenous to Indiana, by Stanley Coulter.

*Twenty-fifth Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1900.

Contents: Portland Cement, by W. S. Blatchley; The Lakes of Northern Indiana and their Associated Marl Deposits, by W. S. Blatchley and Geo. H. Ashley; Oölite and Oölitic Stone for Portland Cement Manufacture, by W. S. Blatchley; The Silver Creek Hydraulic Limestone of Southeastern Indiana, by C. E. Siebenthal; The Indiana Oölitic Limestone Industry in 1900, by C. E. Siebenthal; Reports of the State Natural Gas Supervisor, State Inspector of Mines, Supervisor of Oil Inspection; The Petroleum Industry in Indiana in 1900, by W. S. Blatchley; The Devonian Fossils and Stratigraphy of Indiana, by E. M. Kindle; On a Small Collection of Batrachians, with Descriptions of Two New Species, by W. S. Blatchley.

*Twenty-sixth Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1901.*

Contents: The Mineral Waters of Indiana, by W. S. Blatchley; The Medicinal Properties and Uses of Indiana Mineral

Waters, by Robert Hessler; A Geologic and Topographic Section Across Southern Indiana, by J. F. Newsom; The Petroleum Industry in Indiana in 1901, by W. S. Blatchley; Reports of State Mine Inspector, State Natural Gas Supervisor and State Supervisor of Oil Inspection.

*Twenty-seventh Annual Report of the Department of Geology and Natural Resources.* W. S. Blatchley, State Geologist, 1902.*

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# GENERAL INDEX TO ALL THE PUBLICATIONS OF THE INDIANA GEOLOGICAL SURVEY, THE DEPARTMENT OF GEOLOGY AND NATURAL HISTORY, AND THE DEPARTMENT OF GEOLOGY AND NATURAL RESOURCES.

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By T. C. Hopkins.

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*Coal. For complete description of the Indiana coals see the 23d Ann. Rept. for 1898, which includes an extended illustrated monograph on the coals of Indiana, by G. H. Ashley.

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